INDEXED.

International Marine Engineering

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THE BAR HARBOR STEAMER MOOSEHEAD.

The *Moosehead* was built for the Maine Central Railroad Company by the Bath Iron Works at Bath, Me. She was designed by the Bath Iron Works for the particular passenger service of the Maine Central Railroad Company between Mt. Desert Ferry and Bar Harbor, and other points in Frenchman's Bay, in connection with the railway service. This service is very similar to that maintained by the Central Railroad of New Jersey between New York City and Atlantic Highlands; by the Chesapeake & Ohio between Newport News and Norfolk, and by the New York, Portsmouth & Norfolk Railroad from Cape Charles to Norfolk. The *Moosehead* is intended to carry passengers, baggage, mail and horses, with little freight, and that of the highest class. She is a twin-screw steamer of the following dimensions:

THE NEW PASSENGER, BAGGAGE AND MAIL STEAMER MOOSEHEAD, FOR SERVICE IN FRENCHMAN'S BAY.

Length over all	194 feet 11 inches.
Length load waterline	185 feet 10 inches.
Beam over guards	36 feet 8 inches.
Beam molded	30 feet 6 inches.
Depth molded	14 feet 6 inches.
Draft forward on trial	10 feet ½ inch.
Draft aft on trial	10 feet 8½ inches.
Mean	10 feet 4½ inches.
Displacement on trial	664 tons.
Area immersed 'midship section	234 square feet.
Block coefficient	.4066
Prism coefficient	.552

The *Moosehead* is one of the finest finished vessels of her type in the country, as well as one of the fastest; 19 miles an hour being the contract speed and 19.75 being maintained on her four-hour contract trial. She has been very carefully designed throughout, and is classed A-1 for seventeen years with the American Bureau of Shipping. She is licensed to carry 800 passengers.

In order to obtain the necessary horsepower and the most suitable form of hull, to carry out the programme laid down by the railroad company, her model was towed at the naval experimental tank at the Washington navy yard.

The hull is of steel up to the saloon deck, steel bulkheads and sides forming the structure between main and saloon decks, instead of using wooden studding and sheathing, as is usually the case in vessels of this type. The engine and boiler casings are entirely of steel from the main deck to the top of dome, and the saloon deck is steel plated over the boiler room, in order to obtain air-tightness when the vessel is worked under forced draft. The joiner work on the saloon deck is reinforced by steel channel beams closely stayed, thus insuring an extremely rigid support for this joiner work in the decks, cabins, etc. Ample fire protection has also been had in mind by the contractors. The boat is of the flaring sponson shape, the main frames running up to the guards.

There are five watertight bulkheads as follows: Fore peak, between forward hold and boiler room, between engine room and after hold, after trimming tank and transom frame bulkhead. A non-watertight bulkhead of steel has also been fitted between the engine and boiler rooms. Both boilers are installed in one fire room.

Aft of the engine room on the lower deck are staterooms for the porter, steward, cooks, assistant engineer and oilers. Forward of the boiler room on the lower deck are staterooms for the stewardess, crew's mess room, crew's quarters and firemen's quarters and enclosure for steam steering gear. In the extreme bow are the chain lockers and trimming tank.

The main deck is enclosed to the side of the vessel from the bow aft to the after end of the engine room, aft of which is a passage around the stern outside of the house. In this house are located the entrance hall. dining room, ladies' room and ladies' toilet room. From the entrance hall is a large stairway leading to the main cabin and saloon deck above. Passages run forward from the entrance hall on each side to the baggage space abreast the engine and boiler casings and forward of them. The galley, men's toilet and wash rooms and the chief engineer's stateroom are located just forward of the entrance hall on the passages. Forward of the boiler casing is the mail room and a wide staircase to the saloon deck, entrances to men's room and crew's quarters, crew's

watercloset and lamp room. Wide gangways are cut in the sides of the house forward. On the saloon deck is a house containing a large cabin, at the forward end of which are two ample staterooms, each having a toilet room attached. A comfortable smoking-room is located at the extreme forward end of this house under the pilothouse. The purser's office is built in the main saloon, forward of the boiler casing.

As the *Moosehead* is for day service the saloon cabin is lighted by large plate-glass windows all around, forming a splendid observation room. There is also a very large deck space inside of this house and covered by the gallery deck, which deck extends from the pilothouse to the stern. Permanent seats are fitted around the rail and outside of house on the saloon deck. On the boat deck are the pilothouse, captain's, mate's, quartermaster's and purser's rooms. The boats are stowed on this deck.

Since the vessel is intended for a high class of service, particular attention has been paid to the joiner work, which in the ladies' room, dining room, entrance hall, smoking-room and saloon is of solid mahogany with mahogany carlins overhead in the dome, the spaces between the carlins being fitted with composite board in panel effect, painted in light green. The stairways at each end of the saloon leading to the main deck are also finished in solid mahogany.

Interlocking rubber tiling, in excellent taste, is laid in the smoke-room, pilothouse, lavatories, dining room and ladies' cabin. The main saloon and staterooms are carpeted in dark green and furnished with rattan sofas and chairs specially designed and built for this vessel.

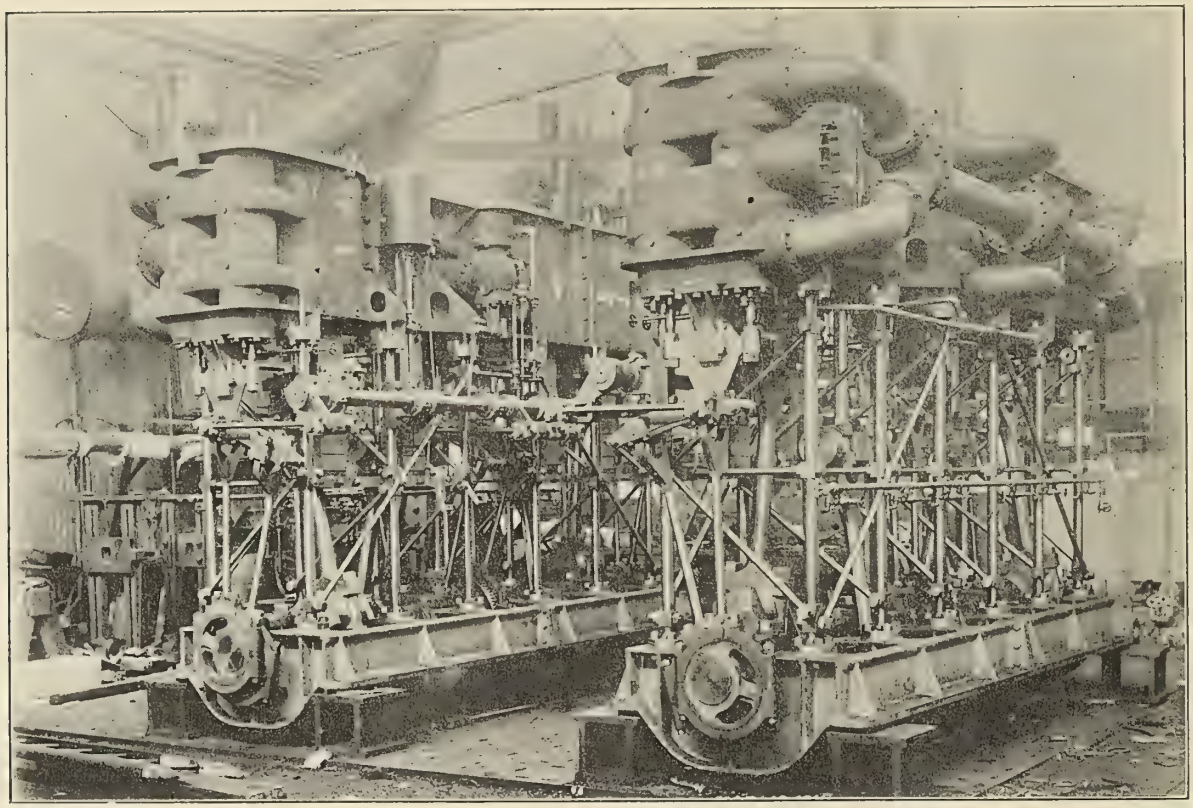
The electric fixtures throughout are of bronze, finished in verde antique. The electric plant consists of two generating sets, each turbine-driven, one of 25 kilowatts and one of 7 kilowatts, located in the engine room. A large searchlight is installed on the pilothouse.

The windlass is of the Hyde hand type, and a combined hand and steam steerer, made by the Hyde Windlass Company, is installed.

The plumbing throughout is of the highest class. The galley is equipped in many respects similar to the kitchen of a dining car, the service being conducted by the dining-car service of the railroad.

The interior communication system is installed by Cory, and consists of mechanical bell pulls, telegraphs, speaking tubes, fire alarms and apparatus to operate both the regular ship whistle and the locomotive whistle, the latter being for entering small harbors on her route, in a fog, on account of the peculiar echo it gives.

The propelling machinery consists of two vertical, four-cylinder, triple-expansion engines, each with one high-pressure cylinder 16 inches diameter, one intermediate-pressure cylinder 26 inches in diameter, and two low-pressure cylinders 30 inches in diameter, all with a common stroke of 24 inches. The cylinders are mounted on turned steel columns suitably braced, the crossheads working upon bar guides. All cylinders have piston valves, both the valves and the liners being ground. Steam reversing gear is installed. Steam is supplied by two Scotch boilers working at 170 pounds pressure and located in a closed fire room equipped with blower and engine. Each boiler is 14 feet 4 inches in diameter and 12 feet 7 inches long, equipped with three Morison furnaces 44 inches inside diameter. There is also an upright donkey boiler installed in the fire-room. One smoke pipe is fitted. The grate area of each boiler is 71.5 square feet, and the heating surface of each boiler is 2,722 square feet. The twin propellers are out-turning, and are solid bronze. Each has three blades, and is 8 feet 6 inches in diameter, 10 feet pitch. Pitch ratio, 1.176; projected area, 2620.8 square inches; disc area, 8171.3 square inches; disc ratio, .321.



MAIN ENGINES OF THE MOOSEHEAD, ERECTED IN THE SHOPS OF THE BATH IRON WORKS.

In accordance with the terms of the contract the *Moosehead* was standardized over the Boothbay mile with the following results:

STANDARDIZATION TRIAL. S. S. MOOSEHEAD. BOOTHBAY MILE

No. Run.	Direction.	Revolutions.			I. H. P.			Speed.	Slip.
		Port.	Starb'd.	Mean.	Port.	Starb'd.	Total.		
1	N	115.3	113.4	114.35	174	176	350	12.46	4.1
2	S	105.7	99.4	102.55	159	141	350	11.25	3.8
3	N	109.5	135.6	122.55	98	283	381	13.38	4.
4	S	150.3	153.9	152.1	382	478	860	15.96	7.69
5	N	156.2	161.3	158.75	447	544	991	16.95	6.
6	S	170.3	170.9	107.6	605	649	1254	17.65	11.66
7	N	178.3	185.8	182.05	717	899	1616	18.83	8.65
8	S	183.8	189.4	186.6	827	967	1794	18.75	11.57
9	N	194.6	195.4	195.	1131	1127	2258	19.65	13.1
10	S	196.7	198.0	197.35	1143	1124	2267	19.38	31.6

Immediately after the standardization trial a four-hour run at full speed was maintained with the following results:

FOUR-HOUR TRIAL. S. S. MOOSEHEAD.

	Port.	Starboard.
Pressures:		
H. P. chest, pounds gage	167.	167.
I. P. chest, pounds gage	74.6	51.7
L. P. chest, pounds gage	10.56	10.6
Vacuum, inches	25.75	25.75
Air in fireroom, inches	1.	
Revolutions		
Main engines	200.55	201.75
Average	201.15	
Air pump	37.25	
Circulating pumps	469.	416.
Average	442.5	
Feed pump	21.25	
Forced draft blower	525.	
Speed, statute miles per hour	19.75	
Slip, percent	13.5	
I. H. P. total, main engines	2341.	

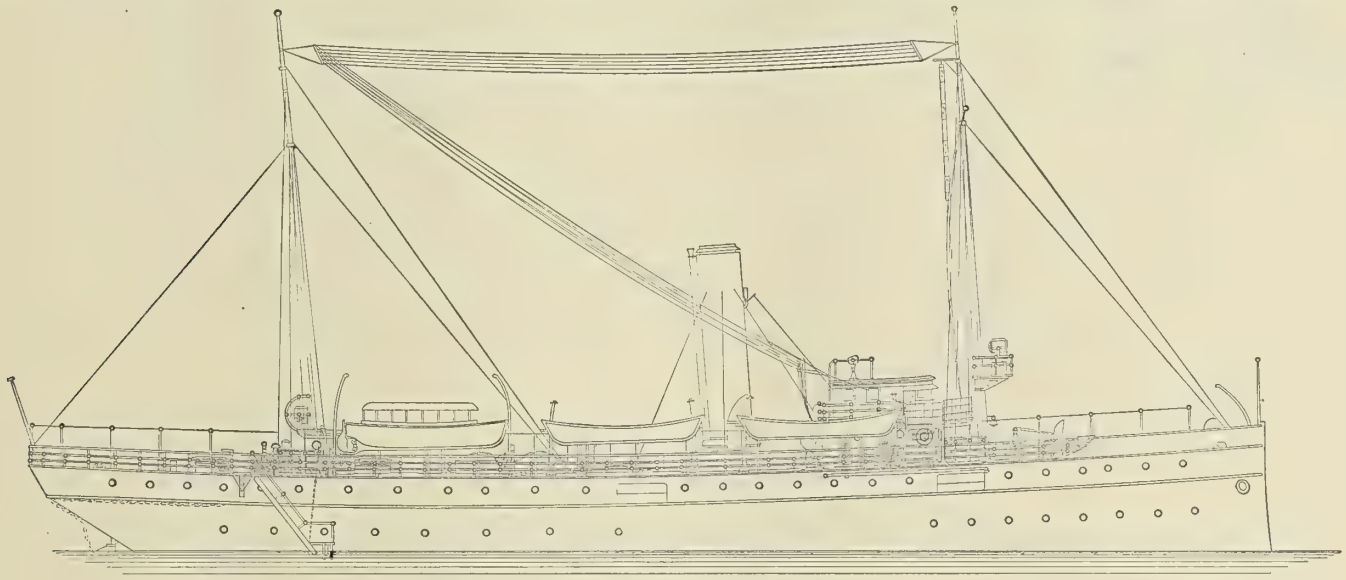
The *Moosehead* was to be delivered under her contract on May 15, and was finished ahead of time. She has been at the railroad company's wharves at Rockland, Me., being outfitted for service into which she entered on June 26.

During the fiscal year ended June 30, 1,527 vessels of 302,391 gross tons were built in the United States and officially numbered by the Bureau of Navigation, compared with 1,502 vessels of 347,025 gross tons for the fiscal year ended June 30, 1910. The decrease is due to a falling off of 65,000 tons in shipbuilding on the Great Lakes, anticipated in Secretary Nagel's report last year. The year's construction comprised 1,123 steam and motor vessels of 246,540 tons, 85 sail vessels of 11,398 tons, and 319 unrigged barges and canal boats of 44,453 tons.

TWO NEW REVENUE CUTTERS.

At the last session of congress an appropriation of $250,000 (£51,400) each for two new revenue cutters was made. Plans have been prepared and specifications drawn for what is considered will be two of the finest ever constructed for this service. The ships will be duplicates in every particular, primarily to reduce the cost of construction, and, secondarily, in order to produce uniformity in the vessels of the first class.

The work of assisting vessels in distress and in searching for and destroying derelicts has grown to such an extent that these duties were given paramount consideration in deciding on the general type of vessel to be constructed. To that end there has been evolved a design of vessel which will give great seaworthiness, large steaming radius and, in general,



DESIGN FOR THE NEW UNITED STATES REVENUE CUTTERS.

to provide all usual appliances for the assistance of vessels in distress.

The principal dimensions of the new vessels will be:

Length over all	200 feet.
Length between perpendiculars	180 feet.
Breadth of beam, molded	34 feet.
Displacement at mean load draft	1,324 tons.
Draft, aft	15 feet 6 in.

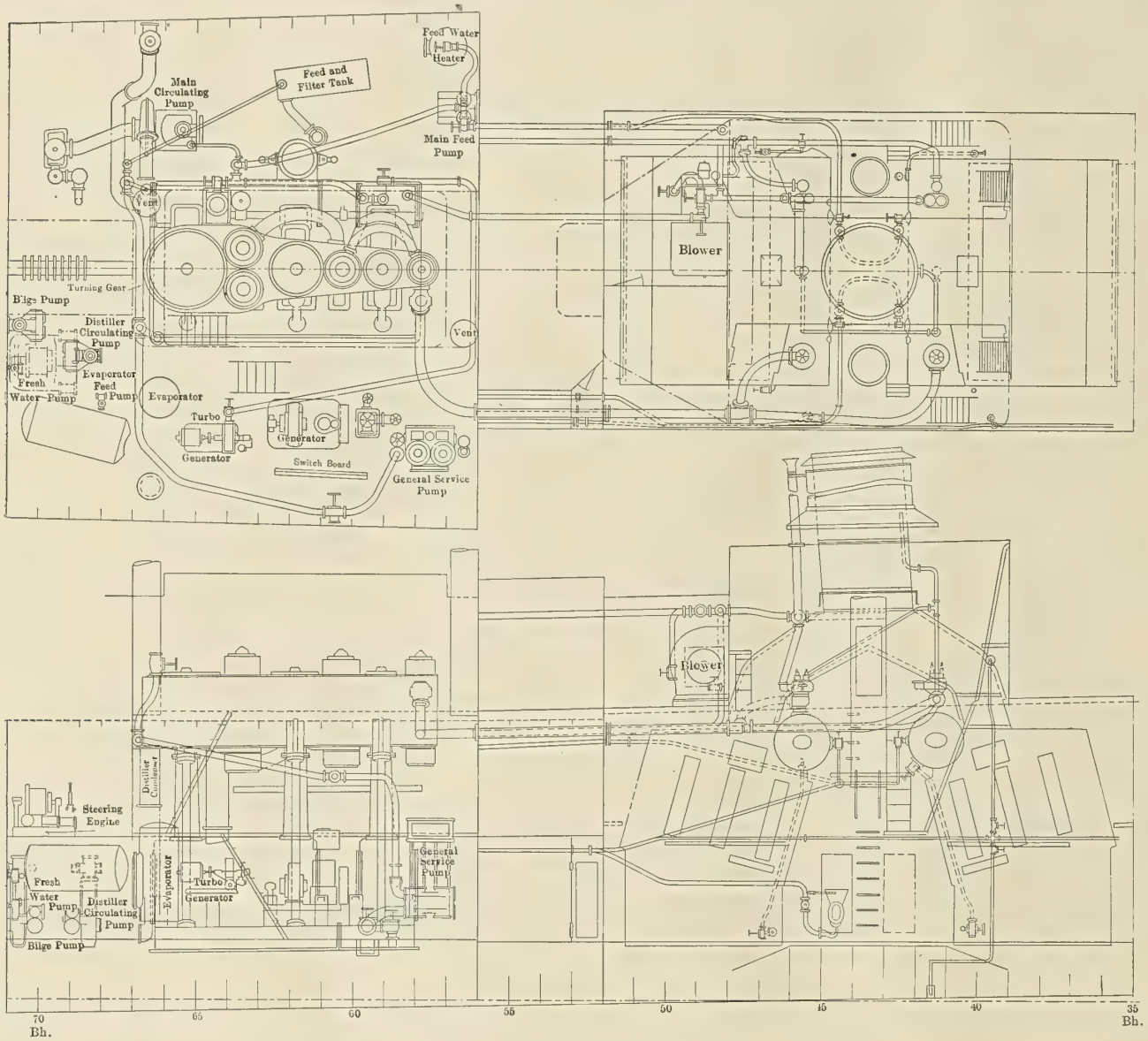
Each will have a flush deck, fore and aft, and be schooner rigged with two pole masts. The stem will be slightly ram-shaped and the stern will be of the overhanging, elliptical type. There are two complete decks, the berth and spar decks, and outside of the machinery space at each end of the ship a partial berth deck. A double bottom extends under the fireroom, which will be utilized for boiler feed water. The only houses on the spar deck will be the pilot house and a small structure around the mainmast for an entrance to the cabin. The living quarters for the captain and the wardroom officers will all be on the main deck, aft; the warrant and petty officers will have staterooms forward on the same deck, while the crew will be berthed in galvanized iron pipe berths, instead of in hammocks, as is usual.

The new cutters will carry six boats, including an up-to-date surf-boat, all of which will stow between the two masts, thus leaving a clear quarter deck where towing lines may swing without obstruction. A large pair of towing bitts and a steam winch will be fitted just aft of the mainmast, as in the

work of the revenue cutters it is frequently found advisable to tow derelicts or disabled vessels into port.

A large magazine, aft, abreast of the shaft alley on the starboard side, will provide safe stowage space for the ammunition to be used in the main battery of four 6-pounder rapid-fire guns and for the gun-cotton mines to be used for derelict destroying.

The new vessels will have a very complete electric installation, consisting of one 20-kilowatt main generating set for purposes



MACHINERY SPACE OF THE REVENUE CUTTERS.

of lighting, and one 8-kilowatt turbo-generator for the wireless telegraphy and emergency set. There will be one 24-inch and one 18-inch searchlight, an Ardois signaling apparatus and a 2-kilowatt wireless telegraph set of the latest type.

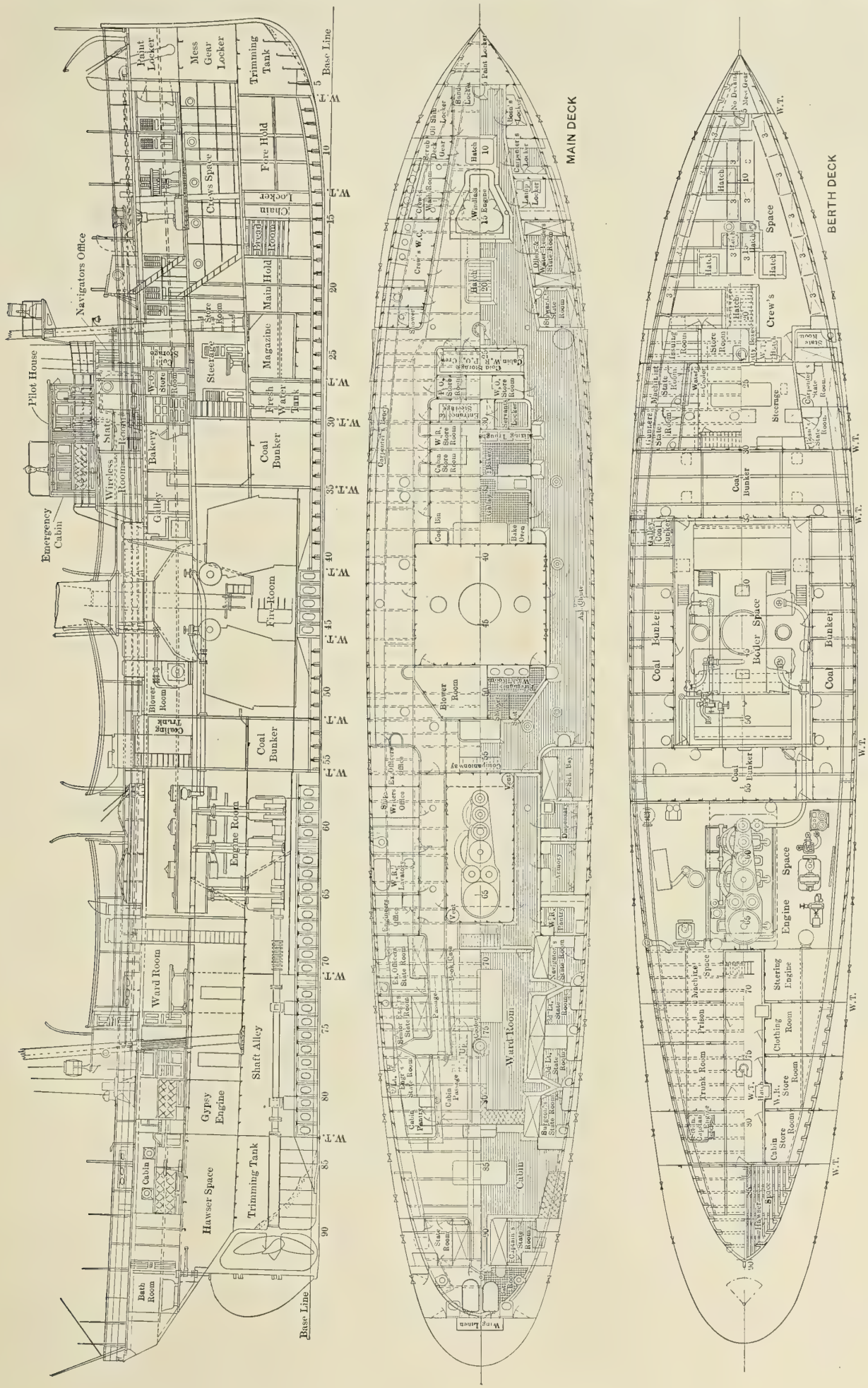
The propelling machinery will consist of two straight-tube watertube boilers, each containing about 90 square feet of grate and 3,150 square feet of heating surface, which will furnish steam at 200 pounds pressure for the main propelling engine. This will be of the vertical, direct acting, inverted, triple-expansion type, having cylinders 20 inches, 32½ inches and 54 inches in diameter, respectively, with a common stroke of 36 inches. All main valves will be of the piston type and it will be noted that their design is such as will reduce the volumetric clearance to a minimum. The surface condenser will be of the ordinary cast type, forming a part of and built in with the back columns of the engine.

A feature of the design is what is presumed to be the first auxiliary condenser ever designed to work in conjunction with the main condenser circulating apparatus. From the design it will be seen that the auxiliary condenser is of the same general section as the main condenser and forms a part of the housing of the high-pressure cylinder. In port, when the auxiliaries only are in use, the main circulating pump will circulate water through the auxiliary condenser by means of pipes connecting the water chests of the main and auxiliary condensers. This avoids the installation of two circulating pumps with the necessary complication of sea valves, pipe connections, etc. The main feed pump will be utilized as an auxiliary air pump and will discharge directly into the feed tank.

There will be a feed water heater, a wrecking pump, ash ejector and, in general, all the accessories necessary for the requirements of a revenue cutter.

It is estimated that the main engine will produce 2,000 indicated horsepower, at the extreme, which should give the vessel a meximum speed of about 15 knots.

The very large bunker capacity for this size of vessel (300



INBOARD PROFILE AND DECK PLANS OF THE NEW UNITED STATES REVENUE CUTTERS.

tons) will give them a cruising radius at economical speed of not less than 5,000 nautical miles, a much desired factor for long cruises in search of derelicts. The vessels will each carry about 16,000 gallons of fresh water.

Congress, as in the case of naval vessels recently authorized, required that these vessels should be built in accordance with the provisions of the 8-hour law. Proposals were solicited for ships of this design, but owing to the restrictions of the 8-hour law shipbuilders refused to bid. Upon modified plans for smaller vessels, embodying most of the essential features, the Newport News Shipbuilding Company has finally been awarded the contract for their construction at a cost of $244,000 (£50,000) each.

MISUNDERSTANDINGS CONCERNING BABBITT METAL.

BY A. A. GREENBURG.

The manufacture and sale of Babbitts has long been a prolific field for the impostor. He has invariably taken advantage of the prevalent ignorance of the purchaser and has done incalculable damage to the reputable manufacturer. The business, in fact, years ago came to such a point that firms who valued their reputation hesitated before entering this field of competition.

There is perhaps at the present time no term in the mechanical world so ambiguous and so misused as the term "Genuine Babbitt." It is popularly believed that "Genuine Babbitt" is the composition originally compounded and invented by Isaac Babbitt, to whom we are indebted for the invention of making soft metal linings for bearings. In United States patent No. 1,252, July 17, 1839, granted to him, a suitable composition is mentioned consisting of fifty parts tin, five parts antimony and one part copper. Now, what his patent specifically covers, and what he claims in the same, is simply the method of application of a soft lining in bearings. The formula given was for the purpose of making his specifications complete for patent office requirements. The value of his invention in his own mind related to the construction of bearings rather than to the production of an anti-frictional metal.

Later, Mr. Babbitt gave the question of the composition of his alloy some thought, and he realized that the hardest alloy consistent with other requirements was the best for him to use. The formula for his favorite composition, which, some years later, he sold to a Mr. Phillips, an American manufacturer, was quite different from that first mentioned in his patent, in that it contained ten parts tin, one part antimony and one part copper. At the outset, Mr. Babbitt himself had no exact composition he used for his linings; wherefore the term "Genuine Babbitt" cannot be used in the sense that it is Babbitt's original composition; and, further, it is impractical and cannot be used as a definite specification.

Still greater uncertainty is brought out by chemical analysis of the different metals sold under the trade name of "Genuine Babbitt." If the term ever meant anything at all it was simply this: that the preponderant constituent was tin and that its two other constituents were were antimony and copper.

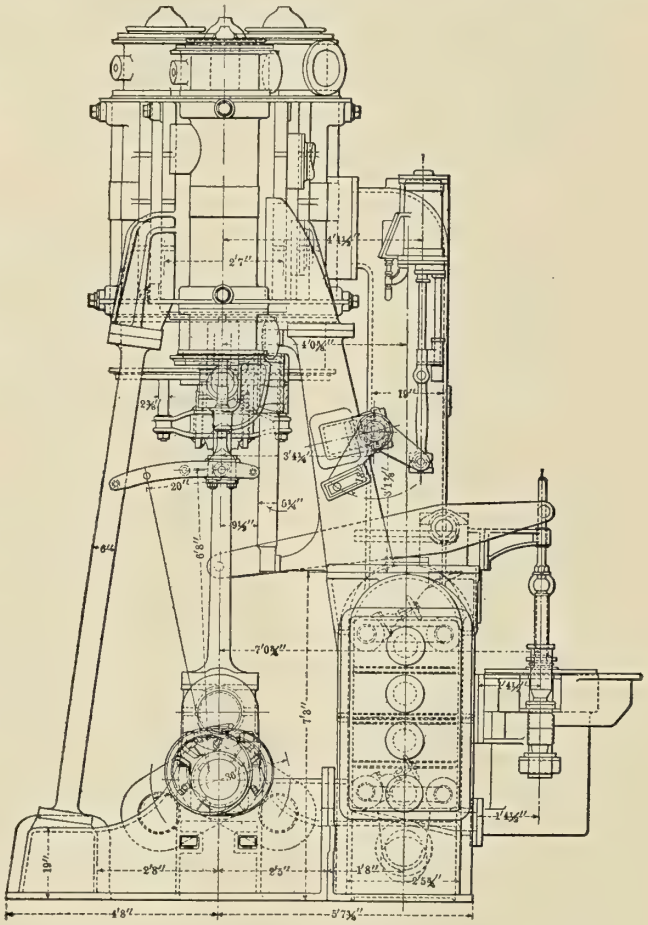
Until recent years the term generally implied that the composition was free from lead. This, however, is no longer the case, because the low cost of antimonial-lead as a by-product for the last fifteen years, and the constant increase in the price of tin, have weighed so heavily upon the manufacturers of "Genuine Babbitt," that to-day the term no longer excludes lead from its composition.

It is, therefore, apparent that this term has outlived its usefulness, and it has been suggested that it be given decent burial in recognition of the respect in which the term was once held. Engineers and machine builders realize that there is no such thing as one universal bearing composition that can be considered as the best and most serviceable alloy for all requirements. Bearing metals should be specified with the same degree of care and precision as any other metal used in the construction of modern machines.

Manufacturers offer alloys of widely different composition, and it is impossible to rely upon fanciful labels and brands. An illustration of this is found in the fact that many makers offer "Genuine Babbitt" of several brands and of as many different compositions. The greatest difference is probably in the matter of price, so that the buyer who desires a "Genuine Babbitt" may choose various grades, prices and compositions; still, they are all classed as "genuine."

Ethically, this is ridiculous, but practically it is not necessarily harmful. While apparently there should be only one "genuine," there is no reason to believe that Isaac Babbitt's formula of fifty years ago, if taken as a definitely exact composition, should apply to the completely altered bearing conditions of to-day.

There is certainly a great question as to the adaptability of any one formula to the wide range of conditions which must be provided for in these days, so that there is justification for the intelligent manufacturer in departing from any established formula; such action is due to an increased knowledge

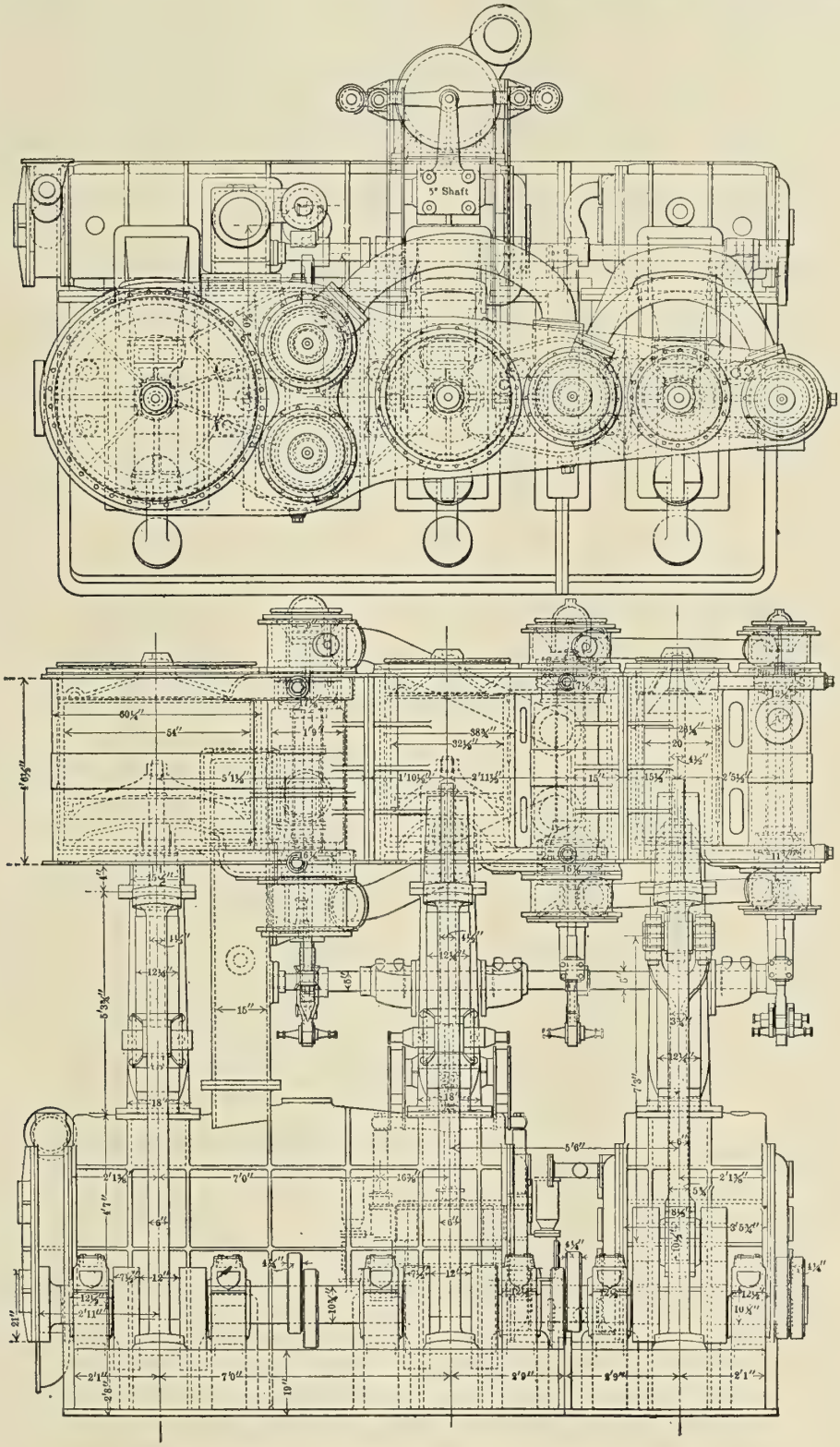


END ELEVATION.

of the metals and metallurgical processes and the necessity for economical construction.

As a matter of fact, nearly all bearing metal requirements could be met with Babbitt's formula of ten parts tin, one part antimony and one part copper. The real merit of a bearing metal lies in its giving satisfactory service at a minimum first

cost. There are, on the other hand, many service conditions where 87 percent lead and 13 percent antimony will answer just as well, and it is a sheer waste of high-priced material to use the former when the latter will do. This illustrates forcibly the extremes of Babbitt compositions. There are also a greater number of intermediate conditions where a very considerable loss is occasioned either by the use of a composition more expensive than is necessary or one that does not have the necessary mechanical qualities to meet the requirements. The metal should be hard enough so that it will not flow or be distorted under service conditions, and at the same time it should not be so hard as to be brittle in case the bearing should be subjected to pounding or unusual strains.



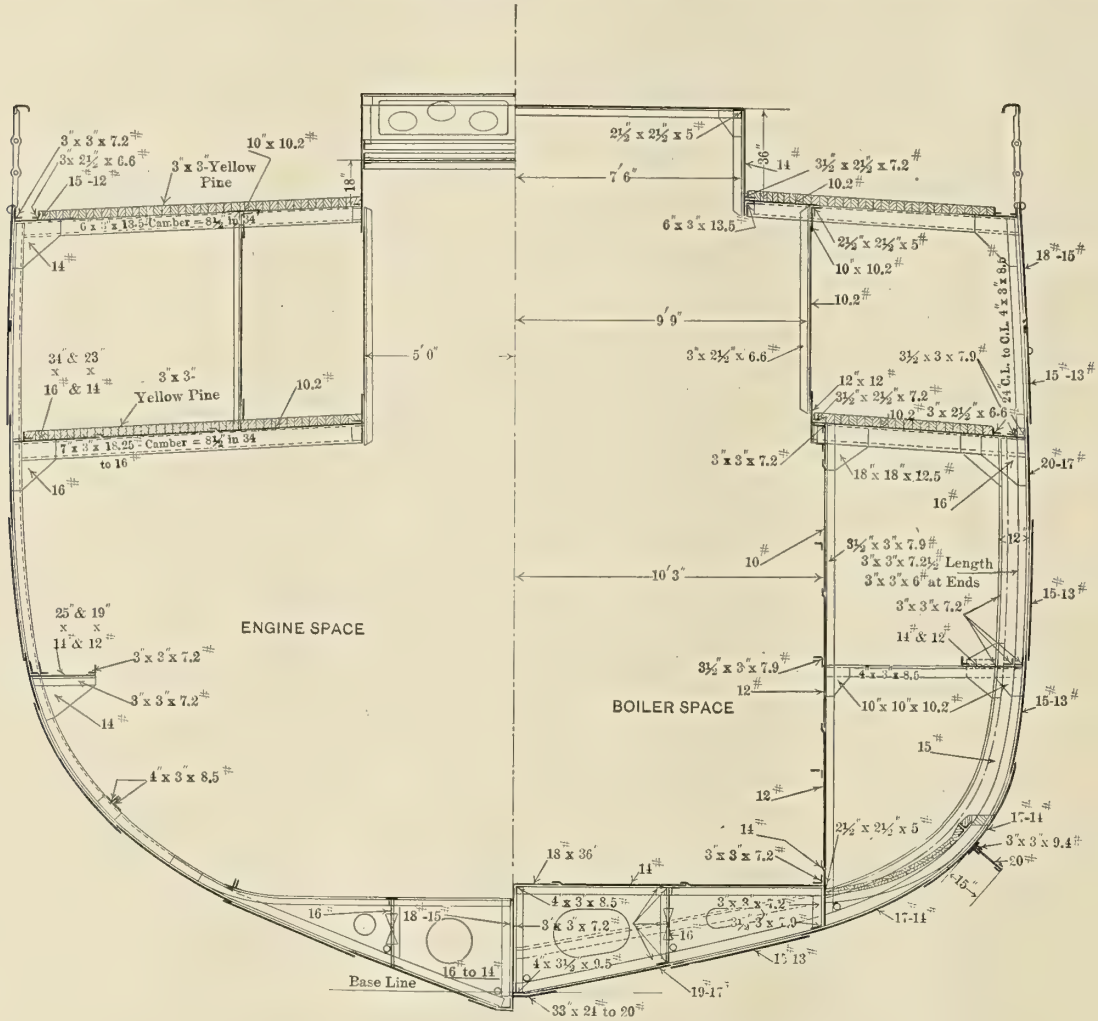
SIDE ELEVATION OF THE MAIN ENGINES OF THE REVENUE CUTTERS.

The efficiency of the alloy, therefore, depends upon the quality of wearing surface that can be produced and maintained under service. A properly selected metal carefully applied, both as to design and workmanship, produces a bearing which with proper lubrication has no metallic contact while running. That

is, the journal and its bearings are separated from each other by a film of oil which mantained in operation; as soon as the movement of the journal is stopped the film of oil is gradually squeezed out and the metallic surfaces are brought into contact. Therefore, in selecting the metals for a bearing they should be sufficiently dissimilar, so that when starting the machine there will be no danger of scoring the shaft until the oil firm shall have been restored.

The heating of bearings is the principal cause of annoyance, and in cases where the metal punishment is so severe that heating cannot be avoided a metal of high melting point should be selected.

Manufacturing methods have a very important bearing on the serviceability of different alloys. The chemical analysis



MIDSHIP SECTION OF NEW UNITED STATES REVENUE CUTTERS.

of a Babbitt, giving the constituents and their relative proportions, is, of course, of some value in determining the quality of Babbitt under consideration; but more important still are certain fundamental, chemical and metallurgical laws according to which the constituents should be united, and if these laws have not been observed a very inferior product will be the result. It is not the purpose here to give a metallurgical treatise but to suggest ideas that should be observed in the handling and applying of lining metals.

In general, these metals should be melted in an iron vessel, and kept covered as much as possible in order to prevent excessive oxidation. They should be heated considerably above their melting point before using, but must not be kept in a molten state at a high temperature longer than necessary. Overheating should be carefully avoided, and a good rule for general practice is to heat the molten Babbitt to a point where it chars a pine stick, at which temperature it casts perfectly. In cold weather the housing and mandrel should be warmed. However, it is not desirable to have the housing as hot as the molten Babbitt, since the slow cooling made necessary thereby would produce excessively large crystals and an undesirable molecular construction.

The analysis of service conditions is the first important step in the selection of the most economical Babbitt for any requirement. The variable conditions of applying a bearing, as well as the care, method and nature of lubrication, all have a distinct effect on the final results. A bearing properly fitted, having the journal perfectly true and polished and the surface accurately scraped, will work under far more severe conditions than could be imposed upon the same bearing if fitted carelessly or inaccurately; the same is true for poor lubrication. It is, therefore, impossible to lay down a definite set of rules for the exact maximum performance of the different alloys.

The final selection of the bearing metal, the design and construction of the bearing, should be left to one who has had experience, but a few general considerations of the subject should not fall amiss.

Where the service conditions are severe owing to great pressure, a metal having considerable compressive strength is necessary, regardless of what the speed may be, and this condition would require a relatively high percentage of tin. Where there is high speed and the pressure light or moderate,

a metal having a fairly high percentage of lead may be used. In the same manner, with intermediate conditions between pressure and speed, correspondingly intermediate compositions can be selected.

The surroundings of a bearing should also be taken into consideration if they are at all unusual. If a bearing is placed in a position where it is subjected to a gritty dust, a higher grade or a harder metal should be used than what would be required for the same service conditions where dust is not encountered. This is owing to the fact that a soft metal is liable to have imbedded upon its wearing surface the grit surrounding it, a difficulty which with a harder Babbitt is not so likely to occur.

Where a bearing is subjected to outside heat a better quality of metal should be chosen than would be necessary for the same bearing under cooler conditions. This is self-evident, in that all bearings, no matter how well fitted or perfectly adjusted and lubricated they may be, are, under full service conditions, warmer than the surrounding air, and the total work of friction, whether great or small, appears in the bearing in the form of heat. The heat given off by a bearing is a direct measure of the amount of the total working friction in that bearing.

The question of care and attention that a bearing receives should also be taken into consideration. A bearing that is lubricated at long intervals or with a poor grade of lubricant requires a higher grade of metal than that which would be required under more favorable conditions.

There is nothing very difficult in making Babbitt suitable to any kind of service. It is only necessary that the work be done by an experienced metallurgist. *Right here* is where we see the importance and value of dealing with a maker whose experience and reputation are above question, and who produces alloys of high quality and sells them honestly at fair prices.

NEW COLLIERS AND TUGS FOR U. S. NAVY.

On June 20 last bids were opened at the Navy Department, Washington, for four naval colliers and two tugs. In the number of colliers were included the two for which bids were received in November last, but which could not then be considered, owing to either an excess over the limit in the appropriation or to irregularities in the submission of the bids. The law governing the construction of these two colliers must conform with the provisions of an act entitled "An act relating to the limitation of the hours of daily service of laborers and mechanics employed upon the public works of the United States and of the District of Columbia," approved Aug. 1. 1892, which means in defined words an eight-hour workday.

The two colliers authorized by act of Congress, approved March 4, 1911, as well as the tugs above mentioned, are not subject to the act above cited, its provisions having been eliminated. The Maryland Steel Company, of Sparrows Point, Md., submitted the lowest bid for the construction of the colliers Nos. 11 and 12 (not subject to the eight-hour workday), their bid being $961,000 (£197,000) for each.

The Newport News Shipbuilding & Dry Dock Company, Newport News, Va., submitted bids for the construction of all four of the colliers, Nos. 9 and 10 (subject to the eight-hour law) at $975,000 (£200,000) each, and Nos. 11 and 12 at $995,000 (£204,000) each. The ships being practically alike, the difference between the two bids would approximately represent the difference in cost of construction to this company under the eight-hour law as compared with standard practice.

The New York Shipbuilding Company, Camden, N. J., submitted the lowest bid for the construction of the two seagoing tugs at $194,000 (£40,000).

COLLIERS NOS. 11 AND 12.

Their chief characteristics are contained in the following: They are single-deck vessels, about 530 feet long, 65 feet beam and 27 feet 6 inches mean draft. Speed, 14 knots at load draft. All the ship's scantlings and arrangements of bulkheads, etc., will meet the general requirements of the American Bureau of Shipping.

In full-load condition the vessels must have a continuous sea speed of 14 knots when carrying 12,500 tons of coal, inclusive of bunker, with an additional 250 tons covering other items.

They have a double bottom extending under the cargo-carrying spaces, as well as under the engine and boiler rooms, while the forward and after-peak compartments will be arranged as trimming tanks. Arrangements for carrying fuel oil in bulk will also be provided for.

The vessels will be fitted with complete coal-cargo handling appliances, consisting of necessary masts, derricks, elevated rails, reversible winches, etc., arranged in such a manner as to deliver coal at rate of about 100 tons per hour from each main cargo hatch, making a total delivery of about 1,200 tons per hour. All necessary pumps, piping and connections will also be provided for handling oil cargo.

Each vessel will have an electric plant, electrically-driven ventilation fans, all suitable appliances for interior communications, such as engine and steering telegraphs, voice tubes and telephones.

An efficient pumping and drainage system will be installed for filling and emptying ballast and trimming tanks, together with a fresh and salt-water system for use in galleys and quarters. A steam heating system will be installed. Accommodations, with staterooms, will be provided for commander, executive and navigating officer, senior engineer officer, three watch officers, doctor, paymaster, two warrant machinists, besides crew's accommodations.

The propulsive machinery will consist of twin-screw, triple-expansion engines of the merchant marine type, and of adequate size for the speed stipulated. The boilers will be of the cylindrical type, with separate combustion chamber for each furnace. A donkey boiler will be fitted for use in port. All necessary auxiliaries will be installed, including evaporators, feed heaters, refrigerating plant, steam reversing engine, steam turning engines and ash hoists.

SEAGOING TUGS.

The general features for each of the tugs are:

Length between perpendiculars	175 feet.
Length over all	183 feet.
Breadth, molded	34 feet.
Breadth, extreme over guards	35 feet 6 inches.
Draft, trial condition, aft	14 feet.
Draft, trial condition, forward	15 feet.
Displacement	1,100 tons.
Total bunker capacity about	435 tons.
Continuous sea speed	14 knots.

The vessels will be built to have the highest rating provided for by the rules and inspection of one of the registration societies. The ships to be fitted with all modern appliances, such as steam capstan and windlass, a reversible steam winch for each of the two cargo booms, steam steering engine, refrigerator and evaporator plant, electric plant and wireless telegraph apparatus, etc.

The propelling machinery for each will consist of a merchant marine triple-expansion engine and two cylindrical boilers, with all necessary auxiliaries.

THE POWERING OF MERCHANT SHIPS AND DESIGN OF THEIR FORMS.

BY PETER DOIG.

To those who are familiar with the assembling graphically of progressive trial results in Admiralty constant form, the task of rendering the curves obtained amenable to law must seem one with much inherent difficulty. The Admiralty constant, or displacement coefficient, as it may be better termed, is familiar to all, being the value

$$K = \frac{D^{2/3}\, V^3}{H}$$

where D is displacement in tons, V speed in knots and H indicated horsepower. As is well known, this coefficient is not a constant, properly speaking; and it may be well at the outset to remind ourselves of the assumptions underlying it. These are: (*a*) That the resistance varies as the square (and consequently the work done as the cube) of the speed; (*b*) that the proportion between "useful" work, or work not wasted in overcoming machinery and propeller frictions, etc., and gross work of the engines, is always a constant fraction; (*c*) that resistance at any particular speed is proportional to wetted surface, or two-thirds power of the displacement, to which wetted surface is itself approximately proportional. If these were absolute laws then a certain unvarying displacement coefficient would be got at any speed of a given ship, and values varying only as the (displacement)$^{2/3}$ of different vessels would be the rule. The skin or frictional part of resistance varying as the 1.83 power of the speed, the foregoing would very nearly hold if all resistance were frictional between ships of no great difference in length; but the introduction of the wave-making phenomena alters this index considerably. Its value gets higher with speed until at very high velocities, where it again decreases. This gives the curve of displacement coefficients a typical form as plotted on a base of speed-length ratio $\left(\frac{V}{\sqrt{L}}\right)$ When the effect of greater relative waste of work at low speeds, due to lower engine efficiency, is allowed for, a curve is obtained starting high in value and decreasing until very high relative speeds are reached, where, in tropedo craft, for example (at $\frac{V}{\sqrt{L}}$ about 1.6), the line has an approximately level trend.

To clear the way towards some reconcilation of the greatly varying values found, it will be of help to consider the factors affecting it in ships of the same displacement. These may be taken: (1) Speed; (2) fullness or block coefficient; (3) proportions; (4) propulsive efficiency; (5) to some degree, owing to the lesser frictional resistance per unit of surface with increased dimension, length, and (6) form, by which is meant the nature of the horizontal and transverse sections.

Though needing careful treatment in view of all these influencing factors, this coefficient method has maintained its position as a handy and flexible means of estimating power in all shipbuilding countries except France, where a similar but less satisfactory coefficient, involving the area of the fullest transverse section instead of the two-thirds power of the displacement, has been long in use. The writer is convinced that the displacement coefficient can be used in a more general way than is current, although it is no doubt being superseded by the more scientific methods of the model basin. As the naval architects and engineers enjoying the use of such an establishment form a very small number in the profession, the present paper, it is hoped, may be of help to the great majority debarred from such a luxury.

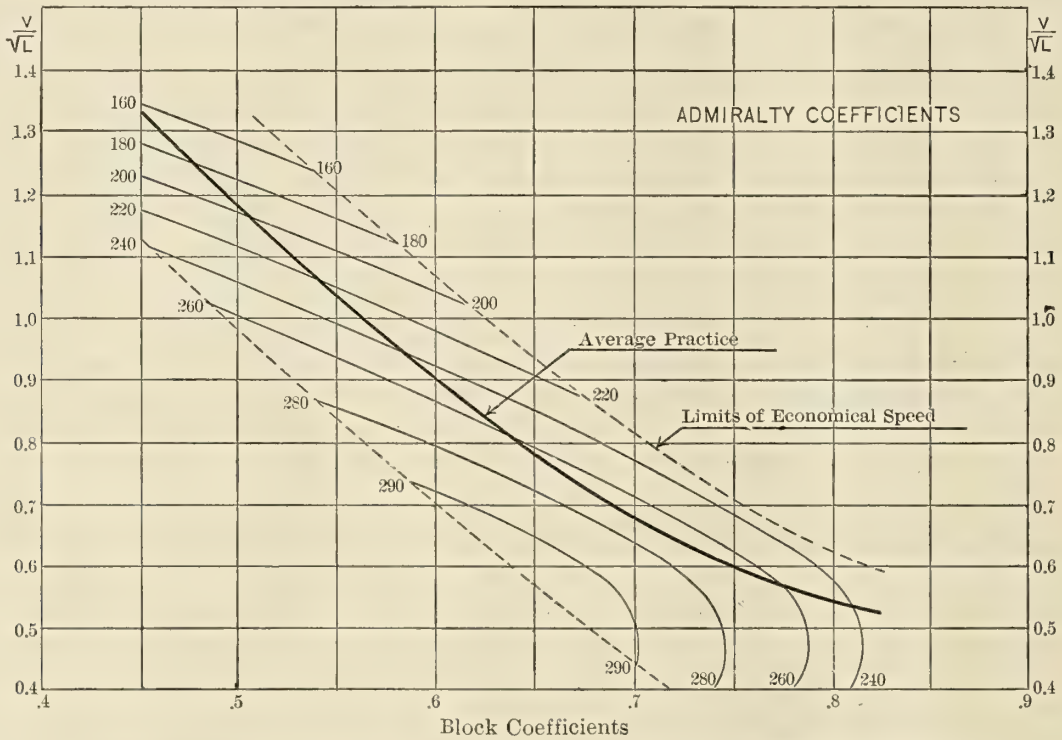


DIAGRAM SHOWING THE EFFECTS OF FULLNESS OR BLOCK COEFFICIENT AND SPEED ON DISPLACEMENT COEFFICIENTS.

An attempt has been made by the analysis of the coefficients obtained in the trials of a large number of merchant vessels to eliminate the effects of the factors enumerated above. As the ships considered are of different builders' designs, the forms should cover most of the practical variations from the normal; so that the effect of number (6) is, so to speak, automatically averaged in the process adopted. A computation of the effect of (5) assuming a standard length of 400 feet, and taking an average proportionate frictional resistance to total resistance (on which the effect directly depends), gives the following corrections:

CORRECTIONS TO K FOR LENGTH.

	Percent		Percent
100 feet less.....	9	500 feet plus.....	1½
200 "	5	600 "	3
300 "	2	700 "	4½
400 "	0	800 "	6

By careful methods the propulsive efficiencies have been estimated for the different ships, using D. W. Taylor's and R. E. Froude's model screw experiments for propeller efficiencies. This disposed of number (4) in a fairly satisfactory manner, though its effect is very large. The propulsive efficiency, or ratio between the effective of "tow-rope" horsepower, and that indicated by the engines, is therefore a measure of the proportion of engine power not used up in the frictional and other losses at machinery and screws, and varies from about .45 to .60. Indicated horsepower absorbed in driving a given ship at a particular speed is inversely proportional to this figure, and it therefore follows that the displacement coefficient varies directly with it. It is plainly seen how great an effect may be produced on displacement coefficients of the same form with different propulsive efficiencies. In the case of number (3) the proportions considered were limited to $\frac{\text{breadth}}{\text{length}}$ values between .105 and .140, and $\frac{\text{draft}}{\text{beam}}$ proportion between .50 and .30. Most merchant ship practice lies in this region, and not much effect due to change of these values was traceable in the coefficients tried.

By plotting the trial coefficients corrected for (5) to 400 feet standard waterline length, and for (4) to .50 propulsive efficiency, on a base of block coefficients and ordinates of speed length ratio, curves were obtained showing the effects of fullness and speed on displacement coefficients. Hence in a more or less satisfactory way the effects of (6), (5), (4), and *for the porportions concerned* (3), are eliminated, leaving the influences of (2) and (1) shown on the diagram. A guide to its formation was found in the published tank results of D. W. Taylor, H. Sadler and others, by the reduction of the results of the forms experimented onto displacement coefficients of ships 400 feet long with .50 propulsive efficiency, some addition to the resistances being made for bilge keels, bossings, etc. It must be borne in mind that only forms falling within the range of proportions mentioned are represented by the diagram; so that shallow river craft, for example, are excluded. However, a great proportion of the mercantile marine, including most ocean-going and a large part of coastal and inland-water ships, are suited by the curves.

A progressive trial, when put down in displacement coefficient form, shows often a maximum value at speeds higher than that indicated by the diagram. This seems to be due to the lower propulsive efficiencies, through greater proportionate frictional waste at engines, at speeds lower than the maximum designed speed.

In setting down the coefficients at the full speeds attained in each ship it was found that they clustered along a line which has been marked average practice on the diagram. This gives what practice has sanctioned as the appropriate fullnesses for particular speed-length ratios. By taking suitable proportions (from similar vessels) a useful rough approximation to displacement may be got, where the known particulars are length and speed, or limiting draft and speed. The figures of size and displacement obtained will serve as a guide in the estimation of the weights of hull, machinery, fuel and deadweight carried; which total, of course, will equal displacement. The top line of the diagram represents the limits of economical propulsion, above which comparatively inordinate expenditure of power would be incurred, and the breadth of the diagram has been limited to the range of maximum trial speeds found in practice, though, as before remarked, these cluster more or less about the average practice line.

In estimating a likely displacement coefficient for a new design the writer has found the values in the following table useful. The multipliers given include the effects of length and propulsive efficiency for the classes tabulated; but it is suggested that possessors of data should find suitable figures for themselves:

TABLE I.

Type.	Length, Feet.	Screws.	Machinery.	Speed, Knots.	Block Coefficient.	Multipliers.
Coasters.	200 to 300	Single.	Reciprocating.	12 to 16	.50 to .65	.82 to .90
Freighters.	200 to 300	Single.	Reciprocating.	8 to 12	.65 to .85	1.02
	300 to 400	Single or Twin.	Reciprocating.	9 to 15	.65 to .85	1.06
	400 to 600	Single or Twin.	Reciprocating.	10 to 17	.65 to .85	1.12
Fine Passenger.	250 to 400	Twin.	Reciprocating.	16 to 23	.45 to .60	1.07 to 1.14
	250 to 400	Twin or Triple.	Turbine.	20 to 25	.45 to .55	1.00 to 1.05
Intermediate Liners or Mail Steamers.	400 feet upwards.	Twin.	Reciprocating.	14 to 20	.60 to .70	1.04 to 1.09
		Triple.	Turbine or Combination.	16 to 20	.60 to .65	1.00 to 1.05
Fast Liners.	500 feet upwards.	Twin.	Reciprocating.	20 to 23	.55 to .62	1.03 to 1.07
		Triple or Quad.	Turbine.	20 to 26	.55 to .62	1.00 to 1.06

As an illustration of the application of this table to the curves the case of a turbine-driven Atlantic liner, 760 feet long, 25½ knots speed, block coefficient .59, may be taken. $\frac{V}{\sqrt{L}}$ here is .925, and reference to the diagram gives 245 as the uncorrected coefficient for this fullness and relative speed. From the table it will be seen that this has to be multiplied by 1.05 (as the length of the ship is so great), and the value 257 is given. With a displacement of 37,000 tons the power necessary for the speed is

$$\frac{37{,}000^{2}/_{3} \times 25.5^{3}}{257} = 71{,}500.$$

This ship is the *Mauretania,* and the above figure is a fairly close approximation to her shaft horsepower at the speed.

Perhaps the best way in which the diagram can be made useful is to estimate from exemplar or type ships. Trial data of vessels as near as possibly similar to the new vessel's size, method of propulsion, speed and fullness, may yet differ somewhat in the last two particulars; and here the value of the diagram will be evident. The $\frac{V}{\sqrt{L}}$ values and the block coefficients of the type ships and of the ship proposed (waterline lengths being used) are calculated and spotted on the curves, and the amounts, to be added to or subtracted from the displacement coefficients of the type ships, are seen. A figure, which is corrected for differences of speed and fullness, and averaging the propulsive efficiencies of the exemplar ships used, is then obtained. It remains to be observed that no trials of ships in adverse weather conditions, with foul bottoms or with emerged propellers, have been used in forming the diagram.

TABLE II.

Block Coefficient.	Designed Speed. $\frac{V}{\sqrt{L}}$	Length of Parallel Middle-Body ÷ Length of Ship.	Curve of Cross Section Areas.	Forebody Waterline.	Nature of Forward End Transverse Section.
.86 to .76	.50 to .60	Minimum resistance with .38; 3% greater with .52 to Minimum resistance with .31; 3% greater with .44	Round at ends.	Round. "In other words easy buttocks at each end rather than full below and fine above." (Prof. Sadler.)	Round *V'd* rather than *U'd*.
.73 to .63	.63 to .85	Minimum resistance with .28; 3% greater with .40 to Minimum resistance with .10; 3% greater with .18 About 6-10 of p. m. b. in forebody.	Hollow forward end "with a given set of dimensions and displacement a long middle-body forward with a fine bow, but more gradual diminution aft." (Sadler.)	Hollow forward end. Rounder aft. Hollowness of waterline forward confined to about 15% ship's length from bow.	*U'd* or "clubbed.'
.63 to .53	.85 to 1.10	Minimum resistance with .10; 3% greater with .18 diminishing to 0 at .6 block coefficient, below which p. m. b. seems undesirable.	Slightly hollow forward.	Slightly hollow forward end.	*U'd*.
.53 to .45	1.10 to 1.35	No p. m. b.	Hollow forward and aft.	Straight, especially above $1.2\frac{V}{\sqrt{L}}$	*V'd*.

THE DESIGN OF FORM.

As the experimental researches of the Froudes, Taylor, Sadler and others on ships' models (see International Marine Engineering, 1905, p. 286; 1909, p. 319) have shown differences in resistance due to varying amount of parallel middle body, varying position of fullest section, and different nature of waterlines, etc., even in vessels of the same proportions and fullness, it can be seen that the writer's statement that only average forms are represented in the diagram is a reasonable one. It may here be of interest to sum up the main results of the experimenting of these authorities, and in doing so the dicta of R. E. Froude (Transactions Institute of Naval Architects, 1904) will be of great assistance in enabling us to concentrate on the major variables concerned. He says: "So long as no unfair features are introduced, such as may cause serious eddy-making, we may almost say that the resistance of a form is determined solely by (*a*) the curve of cross-section areas, together with (*b*) the extreme beam,* and (*c*) the surface waterline of the forebody; and if these are adhered to the lines may be varied in almost any reasonable way without materially increasing or decreasing the resistance at any speed."

*The effect of change of beam on displacement coefficient is not necessarily so great as on resistance. For, with given length, block coefficient, and $\frac{\text{draft}}{\text{beam}}$ proportion, displacement is greater with greater beam; so that (displacement) 2/3 in the denominator of the expression increases and offsets to some extent the increase of indicated horsepower following greater resistance. This probably explains to some extent the small difference found by the writer between the coefficients of ships with $\frac{\text{beam}}{\text{length}}$ proportions so diverse as .105 and .140, so long as block coefficient and speed-length value are the same.

It was long a widespread belief that fineness of midship section is favorable to speed. This is implicitly controverted by the foregoing statement, which has been corroborated lately in the Washington model basin. Naval Constructor Taylor says: "Among the very large number of model experiments we have made, we have had no results indicating any material influence of shape of midship section upon resistance," and that "the naval architect may vary widely midship section fullness without material beneficial or prejudicial effect upon speed."

It may be taken that (*a*) includes the parallel middle-body features, and obviously (*c*) determines the nature of the forebody transverse sections, a round waterline (*i. e.*, one convex outwards), meaning generally V'd sections, and a hollow waterline tending to give "clubbed" or U'd shapes. Some experiments of D. W. Taylor give the best proportions of parallel middle-body to length of ship for certain fullnesses; those of Professor Sadler on full forms give the effect of altering the waterline shapes, and, consequently, the transverse sections; and R. E. Froude's researches on hollow versus straight lines are now famous. The following table presents the main features of good forms; and it may be admitted that better results than indicated by the displacement coefficient diagram could probably be got in ships conforming to the requirements in Table II.

It is not suggested that these few particulars sufficiently define a good form for the purpose of design; but they will serve as a guide for betterment in working from previous designs, if carefully made use of. The characteristics of the various fullnesses shade into each other, but the divisions indicate approximately where one quality ends and the other begins.

Hitherto the accepted opinion has been against any hollowness in waterlines, but model basin experiment has proved their merit in certain cases. Mr. MacEntee has found, from the stream-line theory, that "hollow waterlines cause less wave-making disturbance than straight or convex waterlines, and that as the hollowness and fineness of waterlines are increased, the wave-making disturbance decreases to a minimum, after which, if the lines are made still finer and hollower, the wave-making disturbance again increases." Model experiments have verified the substantial accuracy of this theoretical result with moderate fullnesses and relative speeds; but with great fullness or great relative speed round or straight waterlines seem better. As the investigation of Mr. MacEntee was limited to average fullness and speed, and also to too dimensional treatment, the discrepancy is not serious.

The run of the stern of ship forms should, of course, be designed with a view to a good flow of water to the screw or screws; but otherwise from the standpoint of resistance alone, variation of sectional shapes in the forebody is generally of greater influence than changes of the afterbody form.

A Reversible 300 Horsepower 4-Cylinder Oil Engine.

The problem of designing reversible internal-combustion motors suitable for the propulsion of ships has been solved satisfactorily by Messrs. Fried. Krupp, Ltd., Germaniawerft. In fact, the 300 brake-horsepower Diesel motor exhibited by that firm at the recent International Motor Show at Berlin is reversible and capable of regulation within wide limits. The dimensions of this engine are as follows:

Cylinder diameter	13 inches.
Stroke	13 inches.
Maximum speed	450 r. p. m.

The motor is a single-acting four-cycle engine, the air drawn in during the first downward stroke of the piston being compressed during its upward stroke. At the upper dead point the fuel is introduced into the working cylinder by means of compressed air at 133 pounds pressure per square inch. During the first portion of the subsequent working stroke the work is performed.

Any kind of raw or distilled product of petroleum can be used as fuel; besides crude oil, naphtha, paraffin oil, gas oil, coal tar oil and oil gas tar have been lately employed in this engine.

The fuel consumption is one-third of a pint per indicated horsepower per hour, with fuel of 10,000 effective calories. The fuel is led from a tank to the fuel pumps, each of which supplies one of the four motor cylinders. The compressed air required for introducing the fuel is obtained by means of an air pump, and is stored at a pressure of 133 pounds per square inch.

The control is effected by means of cam discs, levers, etc. The admission, outlet and fuel valves are actuated by a common controlling shaft, whereas a shaft located on the opposite side of the cylinder merely controls the outlet valves.

The motor is started by means of compressed air stored at a pressure of 440 to 515 pounds in two cylindrical steel vessels, the capacity of which has been calculated with a view to allowing the motor to be started sixteen times. The controlling levers are shifted into their starting position previous to starting the motor, and after reaching the speed required for ignition are brought back into working position.

An emergency regulator allows the motor to be stopped, in the event of a shaft fracture, by shutting off the fuel supply as soon as the maximum speed is exceeded.

The working cylinders are made of high-class bronze, and are designed with double walls, water-cooled; they are provided with cast iron liners. The base plate and engine frames are made of bronze castings. The main bearings are water-cooled. The driving gear is readily reached after removing special covers in the frame, which are kept closed during operation. The crank-shaft, connecting rod, pistons, etc., are made of high-grade special steel supplied by Messrs. Krupp.

The moving parts are lubricated by means of a compressed oil system, the cylinders being oiled by special pumps. The used oil is collected in the base-plate, and after being cleansed is used over again.

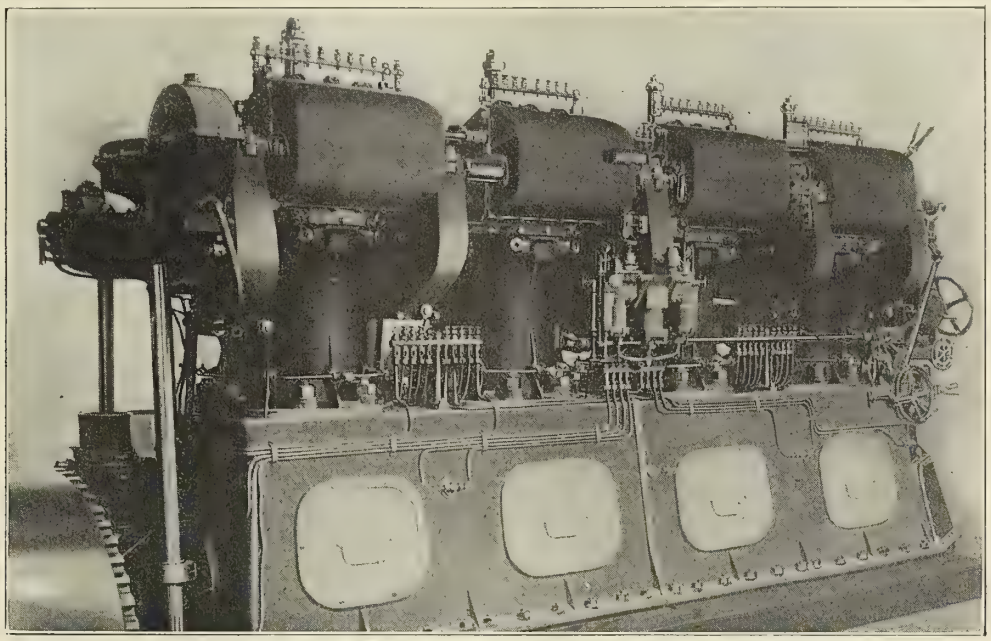
The cylinders and cylinder covers, as well as the exhaust conduits, are water-cooled.

A similar engine was fitted last year in the 25-ton tug *Rapido* of Messrs. Slomann & Company, of Hamburg. This vessel, built at the Lürssen shipyards, is propelled by a reversible six-cylinder motor designed on the system described.

The motor gives the tug a speed of 10½ knots at 400 revolutions per minute; the pull of the boat is 2,640 to 2,860 pounds at 6½ knots. The fuel consumption is only one-third of a pint per horsepower-hour, which compares favorably with that of the best stationary plants.

As demonstrated by the trial runs, made in the presence of a number of interested parties of the military and mercantile navies, the reversing of the motor is as quickly done as with a steam engine. In regard to economy, these motors, which can be readily constructed for any outputs (up to several thousands of horsepower), and are far superior to any steam engine plant, especially where there are frequent fluctuations in load, such as on board tugs, ferries, etc. In fact, the heat losses, unavoidable with steam during intervals of idleness, are done away with, and the motor is ready for operation at a moment's notice without being warmed up. A further advantage is due to the cheapness of the fuel, its less weight and bulk, and the corresponding increase in capacity which increases the radius of action of warships, while the simplicity in operation is such that no skilled labor is required. A further good feature which is of special importance in connection with passenger steamers and warships is the absence of any smoke and soot, the exhaust being entirely smokeless at normal speeds. Again, the crew of the vessel is not inconvenienced by heat radiation, the motors being cooled with water, which will be especially appreciated in hot zones.

Those countries which possess abundant sources of petroleum are likely to soon adopt this novel type of motor for the propulsion of their vessels.



SINGLE-ACTING, FOUR-CYCLE, REVERSIBLE DIESEL ENGINE OF 300 BRAKE-HORSEPOWER.

The first 2,460-ton cruiser for the modern navy of China was launched at Barrow-in-Furness in July.

BALTIMORE FIREBOAT DELUGE.

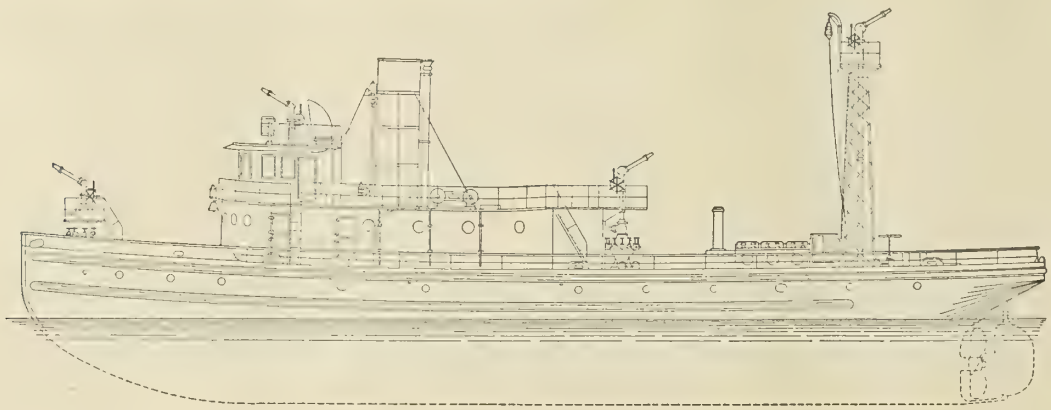
The fireboat *Deluge* has been completed by the Skinner Shipbuilding & Dry Dock Company, of Baltimore, for the Fire Department of that city from designs of Mr. W. I. Babcock, engineer and naval architect, 17 State street, New York. The hull is of steel throughout, 120 feet over all, 109 feet 6 inches between perpendiculars, 28 feet molded beam and 15 feet molded depth, with five bulkheads, three of which are watertight. There is a single deck from end to end, with lower decks forward and aft of machinery space only, all of which hose turret to make a platform for working a large monitor nozzle. A life raft is stowed on top of the deck-house. The steering engine in the pilot house is of the Queen City hydraulic type.

There are no living accommodations on the boat, the quarters for the crew being in the fire house on the pier.

In the engine room are placed two pumping sets with a guaranteed capacity of 4,500 gallons each at 150 pounds pressure. Each set consists of a General Electric Curtis steam turbine and a Worthington centrifugal pump, all on one bedplate and one horizontal shaft. Each turbine has its own sur-

BALTIMORE FIREBOAT DELUGE, UNDERGOING TEST.

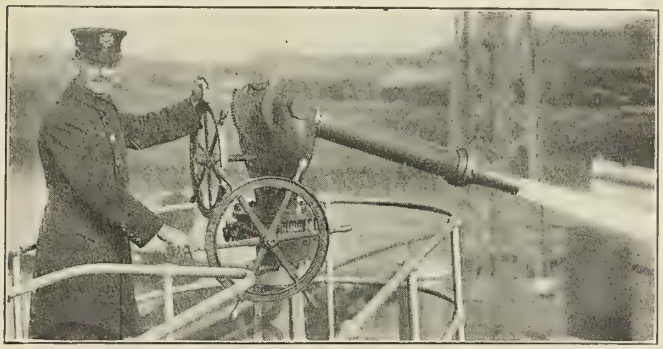
are of steel complete without wood covering. The between decks forward is used for a hose room, with racks capable of holding 2,000 feet of hose, with a hatch through the deck forward of the pilot house fitted with rollers all around for passing the hose on deck. The hold under the hose room and the after peak form fresh-water tanks for make-up feed. The lower deck aft contains only the electric lighting set and lockers for the crew. There is a steel deck-house over the boiler room and coal bunker, the forward end of which is fitted up as a nozzle room with stairway to the steel pilot house above. The after end of this deck-house is extended over the central face condenser, circulating pump and wet and dry vacuum pumps, and all pumps are cross connected, so that either or both condensers may be used with either set of pumps. The main fire pumps are so arranged that they may be worked in series, delivering then 4,500 gallons per minute at 300 pounds pressure. The discharge pipes from the pumps are connected together and lead to a turret immediately over them, to another turret placed at the bow, with a branch to a monitor at the top of the pilot house, and to a monitor at the top of a steel lattice tower on the after deck, which is about 35 feet above the water line.



OUTSIDE PROFILE OF THE DELUGE, SHOWING ARRANGEMENT OF MONITORS.

The engine room also contains the propelling engine, which is of the vertical, inverted double-cylinder, non-condensing type, with two cranks and having cylinders 20 inches diameter by 20 inches stroke, and is of very substantial construction. This engine drives a single four-bladed propeller 8 feet diameter, which is of cast steel.

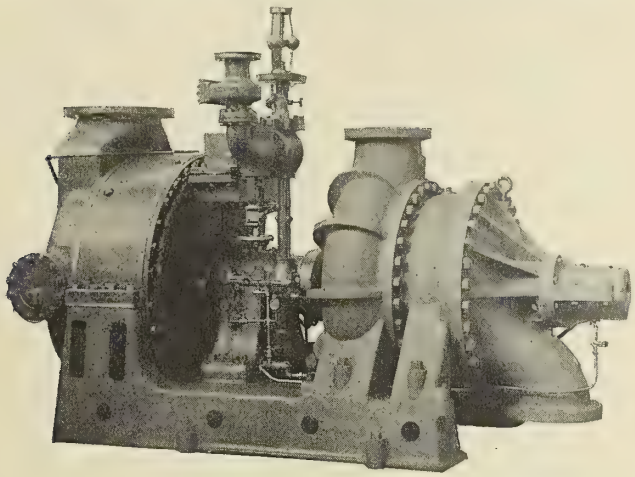
Steam is supplied by two Scotch boilers, 12 feet 6 inches in diameter by 11 feet 6 inches long, allowing 170 pounds pressure, placed abreast of each other next forward of the engine



ONE OF THE THREE-INCH MONITORS ON THE DELUGE.

room, with fire room on forward side and coal bunker next to fire room. Each boiler contains two Morrison furnaces 48 inches in diameter, fitted with separate combustion chambers. The tubes are 2¾ inches diameter. The boilers are fitted with a system of heated forced draft, the blower being placed in a recess in the bulkhead at the forward side of the fire room, and is of the Sturtevant type. The vertical feed pumps are of the Blake type and the feed water heater a Reilly.

The center turret is fitted with twelve 3-inch connections for hose and the bow turret has two 3-inch and six 3½-inch connections. There are four monitors, as shown by the plans, one over each turret, one on top of pilot house and one on the tower aft. These monitors were furnished by Andrew J. Morse & Son, of Boston. The electric light plant has a 10



WORTHINGTON CENTRIFUGAL PUMP, DRIVEN BY A CURTIS STEAM TURBINE.

kilowatt General Electric standard marine set, with about eighty lamps distributed about the vessel, and an 18-inch searchlight on top of the pilot house. The engine room skylight and companionway are of steel complete, with a large number of circular lights, which, as well as the pilot house windows, are of wire-glass.

The pump test took place at the fire boat station in Baltimore harbor, when four 3-inch streams were thrown through the monitors continuously for six hours. The average water pumped during that time was 10,624 gallons per minute at a pressure of 145.5 pounds. The picture was taken during this test. On the trial trip, with 170 pounds of steam, and the wheel making over 150 revolutions, the engine developed 1,100 horsepower and a speed of 15 miles an hour was reached. Everything was so satisfactory that the Board of Fire Commissioners formally accepted the boat at the conclusion of the trial trip, and she went on her station and in regular service the same night.

AN OIL MOTOR FIREBOAT.

A little while ago the council of the London Fire Brigade, England, instituted a competition in order to find out the best design of fire float for use under the very special conditions of service which obtains on the River Thames. The enormous amount of wharfage and of factory buildings, repositories, etc., which congregate on the banks of that river rendered the provision of an efficient river fire service a most important matter, and every endeavor was used in order to utilize as far as possible the most modern fire-fighting mechanism. The result has now become known, and the well-known English firm of boat builders, Messrs. J. I. Thornycroft, Ltd., have now completed and handed over to the London Fire Brigade a motor fire float known as the Gamma, which is shown in our illustration.

The vessel, which is only 66 feet 6 inches long by 11 feet 6 inches broad, was constructed under the supervision of the chief officer of the London Fire Brigade, who worked out the design of the pumping arrangement. The design of the boat provides for motor propulsion and for driving two Gwynne high-pressure centrifugal pumps by the main propelling engine. Each pump has a capacity of 600 gallons per minute at 120 pounds pressure per square inch. Among the special conditions which the design attained was that of draft, which was not to exceed 3 feet 9 inches, and maximum height of any part, which was not to be above 7 feet from the waterline. The guaranteed speed with the two Thornycroft 85 brake-horsepower kerosene (paraffin) motors, driving twin screws, was 10 knots with fuel tanks full and an outfit amounting to 3 tons on board. As a matter of fact, carrying an excess load of 3 tons the boat averaged on trial 10 knots for four continuous hours, with a draft of 1 inch less than the maximum allowed.

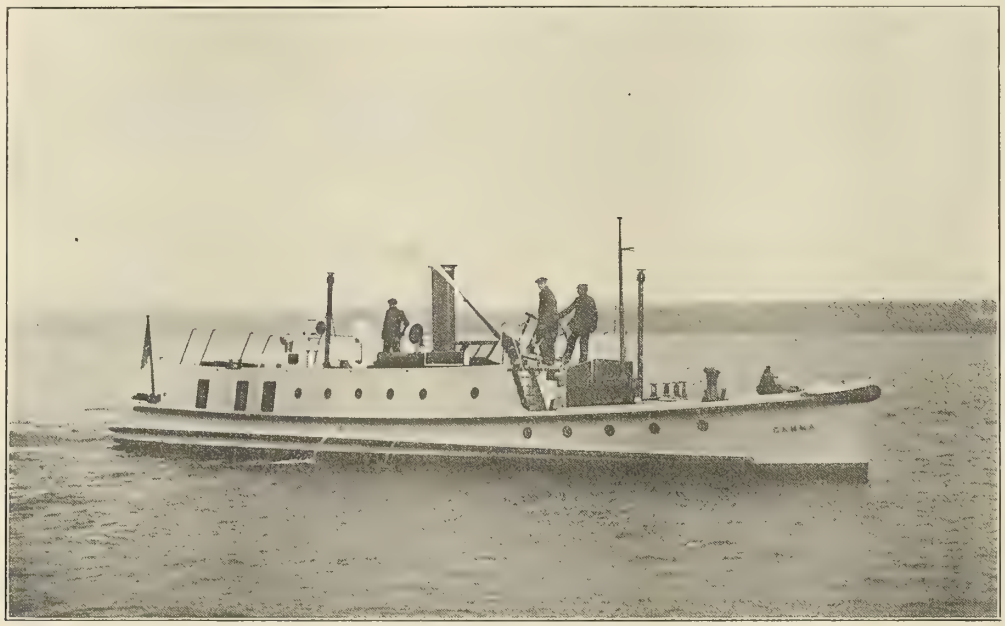
The general arrangement of the vessel comprises a raised deck over the crew space and motor room, giving a clear headroom of about 6 feet 6 inches. The crew space has been made accessible from the after deck by a sliding companion, and accommodation has been provided for three men, with seat berths, table, cooking range, etc. A watercloset has also been provided. Reserve fuel tanks are arranged under the after deck in such a manner that the service tank can be filled by means of a semi-rotary pump. A hose room has been provided under the fore deck, fitted with the necessary racks, etc. This space. as well as the motor room, is heated by hot-water radiators operated from a boiler in the hose room. A storeroom has been arranged forward of the hose room for lamp stowage and for sundry fittings. Steering is effected by means of a hand-gear pedestal, with a brass-mounted teak wheel placed on the forward deck, and leads of wire rope are led to the quadrant aft.

Electric lighting has been provided throughout the vessel and to the navigating lamps. The machinery consists of twin sets of kerosene (paraffin) engines, each giving 80 brake-horsepower at 700 revolutions per minute, and Gwynne's high-

pressure centrifugal pumps. Each engine is connected through a standard reversing gear to a dog clutch, which can connect the main engines either to the propellers or to the pump-driving shaft. The propelling engines have four cylinders, 8 inches bore by 8 inches stroke. They are fitted with a vaporizer of the U-tube pattern, which is arranged to be heated by the exhaust gases. A spirit carburetor is also fitted, so that the engine may be run on gasoline (petrol) with maximum efficiency. The engine is started up on compressed air, which is let into the cylinders on the firing stroke. Gasoline (petrol) is used as a fuel for the first few minutes until the exhaust is sufficiently heated to vaporize the kerosene (paraffin). This takes from five to ten minutes. Should there be no gasoline (petrol) available, the vaporizer can be warmed by a blow lamp. The lubrication is forced, oil being sucked by a small pump from the bottom of the crank case and pumped to the engine bearings through an oil cooler, through which some of the circulating water is by-passed. Ignition is by high tension and also by accumlator and "Lodge" igniter. The reversing gear is of the epicyclic type, the whole going round as one solid drum when in the ahead condition, and the outer drum being held by a brake when in the astern position, which causes the shaft to revolve in the opposite direction. Between the propeller shaft and reversing gear there is a dog clutch, by means of which the engines may be put in connection either with the propeller shaft or with a steel toothed wheel, which is in gear with a compressed paper wheel in the pump-driving shaft. The ratio of gearing is slightly over two to one. The pump-driving shaft is carried alongside the engine on bearings supported by the engine bearers, and drive the pumps through Voith flexible couplings.

The pumps are situated at the forward end of the engine room. These are of the movable high-pressure, four-stage centrifugal type. They run at about 1,450 revolutions per minute, the discharge and suction being 6 inches in diameter. There is a suction box built into the ship on each side, and these are connected by an 8-inch suction pipe, running across the ship, on which are two 6-inch branches to each pump. By this means both pumps can draw through either suction box while the other is being cleaned. A bilge suction box is fitted to the 8-inch suction pipe, with branches to each compartment on deck. There is a monitor or radial delivery, which can be turned in either direction. and also two valve boxes forward, on each of which are four 3-inch sluice valves for hose connections. Two combined electric lighting and air compressing sets are fitted, each of which consists of a 7½ brake-horsepower kerosene (paraffin) engine driving a Siemens dynamo and arranged for driving a Brotherhood rotary compressor through a friction clutch. These are used for pumping up the four bottles in which air is stored at 120 pounds pressure for starting up the main engines, blowing the whistle, etc. Each air compressor set is capable of pumping the air bottles up to 120 pounds in fifteen minutes.

The trials were of a severe character. The speed trial consisted of four hours' full speed trial, followed by maneuvering and turning trials, during which a measured half mile was run with the engines running at 350 revolutions per minute, which demonstrates the flexibility of these engines. For the pumping test each pump had to run for a period of ten hours during the first two hours, of which the output was to be 600 gallons per minute at 120 pounds pressure, and for the remaining eight hours 500 gallons per minute at 120 pounds pressure. Each electric light engine had to be run for four hours continuously. All these trials were carried out to the satisfaction of Lieutenant Sladen, the chief officer, and Messrs. Wells & Kemp, the consulting engineers of the London Fire Brigade. The advent of the motor boat fire-fighting service in Great Britain is therefore an accomplished fact, and in view of the competitive nature of the trials the superiority of the motor-propelled float over its steam rival seems assured.



MOTOR-DRIVEN FIREBOAT BUILT FOR THE SPECIAL CONDITIONS OF SERVICE ON THE RIVER THAMES.

The Italian steamship *Soperga* went ashore on Molasses Reef off Mobile, Ala., in April. The owner of the steam tug *Leroy* asserts that he made a contract with the captain of the *Soperga* to pull her off the reef. This apparently he could not do, and the assistance of other tugmen was asked. After trying in vain to get her off the wrecking vessel *Roosevelt* came along and claims to have floated the vessel. The several owners who joined in the efforts to get the vessel off the reef have libeled her, as no satisfactory arrangement for salvage could be reached.

CARGO HANDLING AT SMALLER PIERS AND TERMINALS.

BY H. McL. HARDING.*

The installation as illustrated is not for the larger terminals or where speed of transference is the most important consideration. For such freight movements the arrangement of the overhead tracks would be considerably modified with a larger number of conveyor hoists.

The purpose is to indicate that a plant could be installed of low first cost and of economical maintenance.

Each installation should be treated by itself from the engineering and operating standpoints.

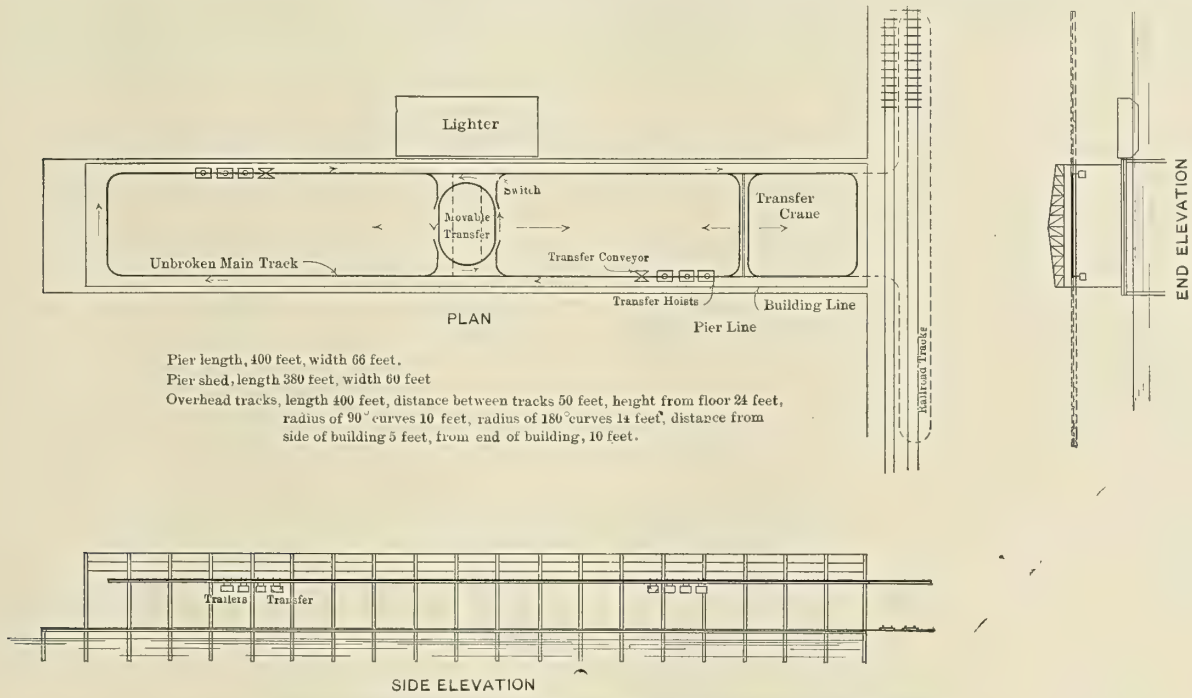
It might be advisable to have the shed reach to the edge of the pier, or that there be traveling bridge cranes with loops (a modified gantry crane) between the shed and the side of the pier, the loop extending over the ship's hatches.

As stated, the following description applies only to the bridges which support the usual hoisting and swinging mechanism of the harbor gantry crane.

In addition to these outside cross tracks there are between the girders of the crane two straight tracks with extension ends, by which the freight can be taken from one side of the pier directly across in a straight line to the other side and deposited within the shed or upon lighters. When not in use they are drawn within the loop. These straight tracks are chiefly furnished when lighters are to be served.

By means of these movable or adjustable cross tracks every foot of floor space can be served by the overhead conveying machinery without rehandling and at the lowest first cost for installation.

The conveying and hoisting machinery, as shown. is arranged in trains, one transfer conveyor drawing after it three or more trailers with hoists. These are designated as transfer hoists. Each transfer hoist is arranged to raise from the draft, which has been taken from the hold in this case by the ship's


Lighter
Switch
Movable Transfer
Transfer Crane
Unbroken Main Track
Transfer Conveyor
Transfer Hoists
Building Line
PLAN
Pier Line
Railroad Tracks
END ELEVATION
Pier length, 400 feet, width 66 feet.
Pier shed, length 380 feet, width 60 feet
Overhead tracks, length 400 feet, distance between tracks 50 feet, height from floor 24 feet, radius of 90° curves 10 feet, radius of 180° curves 14 feet, distance from side of building 5 feet, from end of building, 10 feet.
Trailers
Transfer
SIDE ELEVATION

ARRANGEMENT OF A SMALL PIER FOR THE ECONOMICAL HANDLING OF CARGO.

smaller terminals and is not for universal adaptation. This indicates only one method, but shows that the hoisting or lifting without hand labor is of the greatest importance in securing economy.

The overhead fixed track, as shown in the illustration, consists of an I-beam, upon which is a T-rail of light weight, supported about 5 feet from the sides of the building and arranged at the ends of the building in the form of a loop. Upon side-fixed tracks, corresponding to the usual crane tracks, which are parallel to each other, is operated a traveling shop crane of somewhat greater width between its girders than usual. This crane supports and has attached upon each side of itself a track, which track is so arranged with switches at each end as to afford a smooth passage anywhere between the crane cross tracks and the side-fixed tracks. These cross tracks are supported outside the crane girders. except at the end they join to form a loop and are attached beneath the crane.

In some cases, where there is little headroom, or in open yards, the movable cross tracks can be supported upon whole or half-arch traveling gantry cranes similar to the traveling winch, only those packages in that draft which have the same cross mark. Many managers prefer to use the ship's winches. If there should be four cross marks each transfer hoist would pick up packages having the same cross marks, and each of these four consignments would be conveyed and deposited anywhere upon the floor as may be designated by the cross marks, With four transfer hoists there could be four flatboards, slings, hooks or nets, one to receive each consignment, and all under the control of one transfer man.

This transfer man lowers and unhooks the load as soon as he arrives at the first cross mark pile, even though it be the third transfer hoist in his train, yet this can be lowered first, if desired. One controller is used with the four switches, one switch for each hoist. All four hoists can be raised or lowered at the same time.

By means of the loop track supported by the crane, the transfer conveyor can pass out over the desired location upon the floor and immediately return upon the other side of the loop to the starting point, using the one transfer crane. The two transfer cranes would give a greater rapidity of unit movements than one. The courses which may be taken by the transfer conveyor trains are indicated by the arrows. The

* Terminal engineer.

number of transfer trains can be increased and operated without any interference with one another and without any change in the installations.

The layout, as shown in the illustration, is not intended to have the utmost flexibility and the full continuous rapidity of unit movements as when a more expensive layout is planned, but is for smaller terminals where the intense speed of the greater terminals is not so important as an installation of low first cost and small expense of operation.

At the larger terminals it may be said that rapidity of transference with maximum speed of hoisting is of the first importance.

The capacity of one train with four transfer hoists is about 8 tons. The working possibility of the train depends not so much upon the conveyor and hoists capacity of the transfers as it does upon the size and weight of the consignments. In Providence, the average weight of each rail-borne consignment is about 1,000 pounds. Each train for rail-borne freight would, therefore, average 4 tons per trip. For water-borne freight the tonnage per train per trip would be more, due to the greater weight of individual consignments. Each hoist has a capacity of 1½ to 2 tons. Two hoists combined will raise 4 tons.

By this installation of a plant for smaller terminals there can be effected a saving of at least 18 cents (9d.) per ton in manual labor, including tiering. If, therefore, 300 tons are handled daily it would make a net saving of $54 (£10 16s.) per day in manual labor, or $16,200 (£3,240). On account of the greater speed of loading and discharging the vessel, due to mechanical methods, there would be a greater saving due to this rapidity of movements than as above given as the manual labor saving, depending upon the equivalent of the charter value of the vessel. There would be a greater proportional saving where a larger tonnage is transferred.

By means of a system of simple rollers, which can be placed in position by two men, the freight can be moved easily by gravity from between decks to the hatches more economically and much more rapidly than has been the usual custom. Two or even more ships' winches should be simultaneously operated at each hatchway. From the diagram it will be noticed that every square foot of floor space can be served, including tiering; that there will be no manual labor of rehandling, and that there will be a good degree of continuous rapidity. Should the freight be discharged or loaded at the side ports, the transfer hoists would take it from or deliver to platforms just outside these side ports.

By a more expensive installation the cargo can be taken directly from the ship's hatches in the transfer hoists, which are equivalent to a traveling ship's winch, to any consignment pile or lighter without using the ordinary ship's winch and without any intermediate steps.

The advantages of the gantry crane, which is so extensively installed at many ports over the ship's winch, is not so much the economy in moving the freight from the ship's hold as is its longer inreach from the ship's side.

A standard gantry crane will serve a semi-circular area with a maximum radius of about 45 feet.

The cost of swinging the freight over the ship's side is not the great expense. It is rather the assorting, distribution and transferring by manual labor from the ship's side to the consignment piles (marks and cross marks) within the shed and tiering or to the lighters, which work would be accomplished by the transfer hoists in one train, under the control and direction of one man.

It is the purpose of the attached diagram to indicate how greater economy and rapidity can be attained at smaller terminals by the use of mechanical methods at a low cost of installation.

TWO NEW CHESAPEAKE BAY BOATS.

The *City of Baltimore* and the *City of Norfolk,* recently completed by the Maryland Steel Company for the Chesapeake Steamship Company, are among the finest examples of the luxury to which the traveling public is becoming accustomed and demanding. The designs for these vessels were made by the Maryland Steel Company under direction of Mr. Key Compton, president of the Chesapeake Line, and embody the results of his long experience in the managing and that of the builders in designing and constructing various types of vessels. The general dimensions are as follows:

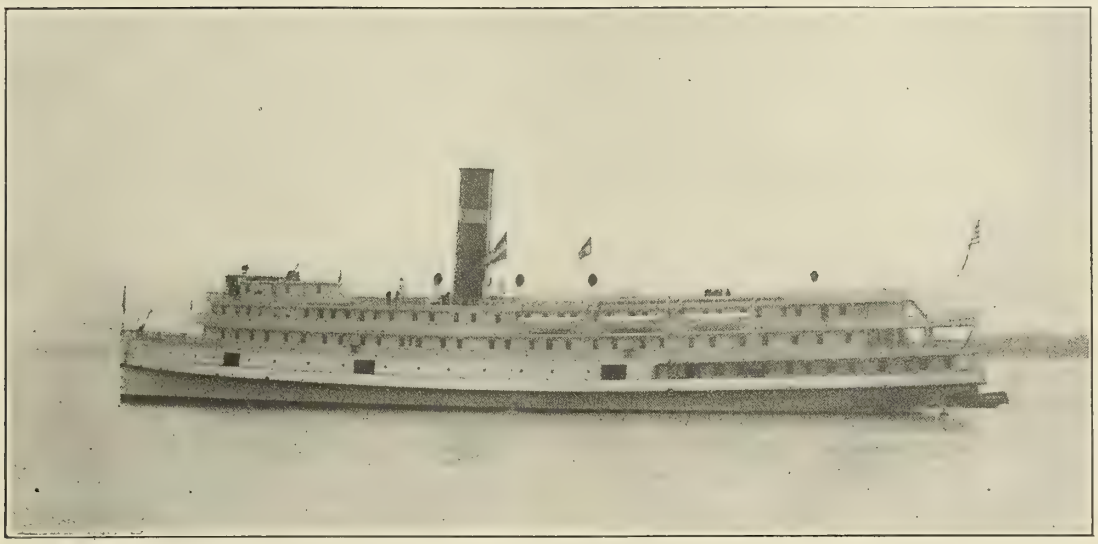
Length over all	310 feet.
Length between perpendiculars	296 feet.
Beam molded	46 feet 6 inches.
Beam over guards	60 feet.
Depth molded	18 feet.
Draft loaded	13 feet 3 inches.

The hull is constructed of mild, open-hearth steel, classed special survey, American Bureau of Shipping, on the usual frame and reverse frame system, with flat plate keel, bilge keels, continuous center keelson and a lower and main deck. The main deck is of steel over the engine and boiler space. Guards are supported by plate knees with slatting on edge. The stem, stern-post and rudder are of best hammered scrap iron. There are seven bulkheads, five of which are watertight.

The accommodations for passengers are most elaborate. There are 120 staterooms, having two metal berths each, ten bedrooms with brass beds and showers, six bedrooms with brass beds and private bath communicating, and eight bedrooms which have a communicating room with double berths. In addition there is a president's room with private bath, a lounge, smoking room or lobby, barber's shop, purser's office and wireless room. The dining saloon is located on the galley deck forward, with pantry and galley immediately aft of same on port side. The general finish is old ivory throughout the saloons; the lobby is finished in selected mahogany, as well as all main starways. Onamental metal balustrades are fitted on all stairways and around the wells. The lounge is finished in old ivory. Opening off the lobby is a commodious bar. All staterooms are fitted with independent heat and running water. The baths and showers are fitted for hot and cold, salt and fresh water. All toilet fixtures are of the very best obtainable. Baths and showers are tiled. Over the well in after saloon is fitted a large skylight with ornamental ceiling, and over main stairs are large ornamental glass domes. The floor of the lobby and dining saloon and treads of all stairs are covered with interlocking rubber tiling. The saloons are carpeted, and all staterooms except those with showers are carpeted. The bedrooms with showers are fitted with hardwood floor and rugs.

All outside staterooms and bedrooms are fitted with intercommunicating telephones and the inside rooms with return call bells. Telephones are also fitted in the president's room, purser's office, bar, wireless and dining rooms, and in the captain's room, chief engineer's room and engine room. The captain has commodious quarters, consisting of office, bedroom and private bath immediately aft of the pilothouse. The first and second officers are immediately aft of this. A private stairway leads from this deck to the gallery deck. The pilothouse is large and roomy and has mechanical telegraphs, engine indicator and running light indicator installed. The chief engineer has a large room on the port side of the main deck just aft of the lobby.

The vessels are fitted with steam windlass, steam steering engines and steam elevator engines. In addition to the steam steering gear an auxiliary hand gear is fitted aft on the saloon



THE CITY OF BALTIMORE, RECENTLY BUILT FOR SERVICE ON CHESAPEAKE BAY.

deck. The life-saving equipment and fire-fighting apparatus are in excess of the United States Steamboat Inspection Rules. There are four elevators for freight service extending from the main deck to the lower hold. The vessels are well lighted throughout by means of bracket fixtures and standards on newel posts of all principal stairways. Current is derived from turbine-driven generators.

Each vessel is propelled by a four-cylinder triple-expansion engines, the cylinders are 24-40-47-47 inches diameter by 42 inches stroke. The boilers are of the single-end Scotch type, 15 feet 6 inches diameter by 10 feet 10 inches long, with three furnaces 44 inches diameter. There are two feed pumps of the simplex vertical piston type, 12-7½ inches diameter by 24 inches stroke, and one fire pump 12-7 inches diameter by 12 inches stroke, duplex vertical, and one sanitary pump for supplying water to the deck as well as water service to the engines of the horizontal duplex type 6-5¾ inches diameter by 6 inches stroke, and one fresh-water pump supplying water to the fresh-water head tank for deck service of the horizontal duplex type, 5¼-4¾ inches diameter by 5 inches stroke. There is one circulating pump, 12-inch suction and discharge, driven by a 9-inch by 9-inch engine. There is one injector for feeding the main boiler, 2½ inches diameter double tube, and one donkey injector for feeding the donkey boiler and washing down, 1¼ inches diameter. There is one feed-water heater of the Griscom Spencer multi-coil type, using exhaust steam from the auxiliary machinery. There are two turbine generators of 30 kilowatts capacity each, of the Terry type, and one generator of 4 kilowatts capacity for port use with reciprocating engine. An open filter box of about 425 gallons capacity and an ash ejector of the hydro-pneumatic type, 6 inches diameter. Attached to the main engine is an Edwards air pump, 22 inches diameter by 14 inches stroke. There are also two bilge pumps attached to the main engine, 4 inches by 14 inches stroke. There is a refrigerating machine forward of the Brunswick type, cooling 5,400 cubic feet room space, and is used for refrigerating perishable cargo and also for domestic use.

The Bureau of Navigation reports 175 sail and steam vessels of 27,225 gross tons were built in the United States and officially numbered during the month of June. Of this tonnage, 61 percent was built on the Atlantic and Gulf coasts and 29 percent on the Great Lakes. The largest vessels were the *Quincy A. Shaw*, of 6,336 gross tons, built at Lorain, Ohio, and the *Hilton*, of 3,102 gross tons, built at Newport News, Va.

BIG BRITISH KEROSENE-ENGINED CRAFT.

BY J. RENDELL WILSON.

A NEW MOTOR OIL CARRIER.

Very few motor commercial boats were more successful on trials than the tank vessel, *Royal Standard*, recently built to the order of the British Petroleum Company by Messrs. John I. Thornycroft & Company, Ltd., of London and Southampton. Destined for service on the lower Thames in connection with the owners' riverside storage tanks, she is constructed of ¼-inch steel plating, and is a fine looking craft for a tank boat. Her fully loaded draft is 4 feet 9 inches. She is 100 feet long between perpendiculars, with a 17-foot molded beam, and has a molded depth of 6 feet 3 inches. As she is intended for river and estuary work only, her design was developed to provide a perfectly flat bottom, with modified V sections forward and wall sides, but with a sharp angle on the bilge.

Her installation is a six-cylinder Thornycroft motor of the four-cycle type, 6-inch bore by 8-inch stroke, developing 70 horsepower at 750 revolutions per minute on kerosene (paraffin) fuel. But the machinery is of special interest, as a solid propeller is driven through a reverse gear and a two-to-one reduction gear, the latter being by Reynolds' silent chain. Furthermore, the whole transmission system, together with the reversing mechanism, is enclosed in a water-cooled casing; an excellent practice, which is very rarely found in internal-combustion engine craft. The engine is on the same center line as, and directly overhead of, the propeller, and the cylinders are all cast in pairs, with all the valves directly operated by a cam-shaft driven by gearing off the crankshaft. Hand starting gear is fitted, and the engine can be started up by one man; but to prevent over-exertion a shaft is carried fore and aft along the cylinders to which a second handle can be fitted in a few seconds. Lubrication is on the pump-gravity system, which the engine builders have found most efficient for marine work. A pump sucking from the crankcase sump delivers to a main pipe running alongside the cylinders, and to each cylinder two small branches are carried, feeding the oil into small cups, thence through piping to main and big-end bearings This allows a chokage to be instantly detected and the obstruction cleared with wire.

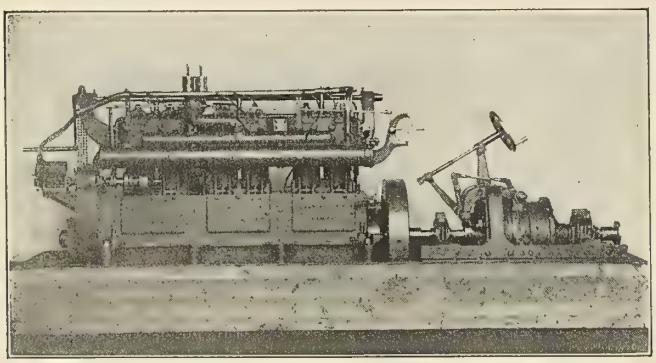
Great care has been taken with the cooling water circulation. A rotary pump delivers the water direct to the exhaust box jacket, thence to the cylinders, through the gear and transmission casing jacket, round the silencer, and finally

overboard. Regarding the fuel, kerosene (paraffin) is used for general running, with gasoline (petrol) for starting, and under normal conditions the consumption is about 5 gallons per hour. The fuel tanks have a capacity of 100 gallons, carried in two main tanks, which gives a cruising radius of nearly 350 nautical miles. As gasoline (petrol) is used for starting, great precautions for safety have been made. This fuel is contained in a 25-gallon tank on the forward bulkhead of the engine room, and is filled from deck through a funnel, fitted with a gauze strainer, screwed directly into the tank. The kerosene (paraffin) supply is also gravity feed, and there is a

THE MOTOR-DRIVEN OIL TANK VESSEL ROYAL STANDARD.

13-gallon tank close by the gasoline tank, and which is fed from the main tanks by a hand-worked semi-rotary pump.

With regard to the general accommodation arrangements of *Royal Standard* there is a roomy forecastle, with seats, locker space, store, etc., aft of which is a cofferdam bulkheaded off, which with a second cofferdam aft and the engine room, provides sufficient buoyancy to render the vessel unsinkable. Next to the forward cofferdam are three oil tanks having a total capacity of 150 tons of oil cargo. Each tank has a pierced baffle or splash bulkhead running fore and aft; and over each tank is an expansion chamber about 5 feet square,



SIX-CYLINDER THORNYCROFT ENGINE FOR THE ROYAL STANDARD.

standing about 12 inches above the deck. Aft of the tanks is the second cofferdam, then comes the engine room, and right aft is a large store. A short pole mast is stepped forward, and over the engine room there is a large cowl ventilator, forward of which is a sheltered steering wheel. During the trials a speed of very nearly 7½ knots was obtained with 100 tons of oil aboard, and with the engine running under the normal revolutions. Needless to say she passed the trials to the entire satisfaction of every one concerned, and is a type of vessel that could well be built in larger numbers.

A ROYAL MAIL MOTOR SHIP.

Probably the largest kerosene (paraffin) engined passenger vessel in the world is the Royal Mail motor ship *Lochinvar,* belonging to the David MacBrayne mail and passenger fleet running the Western Highlands of Scotland. There are, of course, bigger passenger vessels fitted with Diesel engines, but the foregoing statement applies to craft equipped with kerosene (paraffin) motors. Altogether there are three motor ships in the MacBrayne fleet, the other two, *Comet* and *Scout,* being slightly smaller. They are by no means new craft, as the service has been running regularly, but unobstrusively, for nearly four years.

Lochinvar, the latest addition, is a triple-screw steel ship, built at Barling in the early part of 1908. She is 142 feet 2 inches long over all, by 24 feet 1 inch beam, with 7 feet 5 inches depth, and her tonnage is 178 gross.

She is fitted with three six-cylinder Gardner kerosene (paraffin) engines, each developing slightly over 100 horsepower on the brake; that is to say, a total of about 350 indicated horsepower. Solid propellers are driven through a reverse gear coupled to each engine, and the power installed gives her a speed of 12 knots. Two auxiliary motors are fitted, one of 15 horsepower, driving a dynamo for supplying current to the electrical deck gear and for lighting the vessel; while the other, of 7½ horsepower, is required for the compressor, compressed air being used for starting the main engines. A small funnel is fitted aft, to which the exhausts are carried. The passenger accommodation is excellent, there being an upper promenade deck extending the length of the ship, except about 15 feet forward, and there is an excellent dining saloon, also a lounge. In addition to royal mail and passengers she carries a large amount of cargo, and often live stock. Since she was put into commission she has been running very successfully between Oban, Tobermory and Salen, maintaining a very regular and efficient service. The same may be said of her sisters, *Comet* and *Scout,* which are in service in neighboring districts.

An order by the Postmaster-General of the United States was issued on July 21, relating to the establishment of an ocean mail service by 16-knot steamers between leading Atlantic and Pacific ports in the United States and the ports of Colon and Panama. It is provided that the service shall begin in the fall of 1914, so that by aid of the Panama Canal a fast weekly service will be furnished from Atlantic to Pacific ports.

SOME FURTHER NOTES ON CAVITATION.*

BY S. W. BARNABY.

On the occasion of our last International Congress in 1897 I read a paper on "The Formation of Cavities in Water by Screw Propellers at High Speeds."† This was a re-statement of the theory of cavitation which had been brought before the Institution of Civil Engineers by Sir John Thornycroft and myself two years previously. In order to prevent the formation of these cavities we proposed to limit the thrust per square inch of projected surface to about 11¼ pounds per square inch in the case of propellers having approximately the same shape of blade and pitch ratio, and the same depth of immersion as those of the destroyer *Daring*. It was explained that somewhat higher pressures than this could be allowed for screws of finer pitch ratio, or having deeper immersion, or for screws in which the shape of the blade departed from the ellipse, being made broad at the tips. At the time this limit of 11¼ pounds pressure per unit of surface was suggested the use of turbines for marine propulsion was not contemplated,

FIG. 1.

FIG. 2.

and it has been found, as might have been expected, that the uniform turning moment obtained with a turbine enables a higher thrust to be used.

In the case of a direct-driven propeller, where it is necessary to submit to some sacrifice of screw efficiency, in order that the turbine may run at a sufficiently high rate of revolutions for economical working, a thrust of about 13 pounds is accepted, and found to give a good compromise, although I believe that incipient cavitation is then present, causing an increase of slip, because the revolutions usually exceed by 2 or 3 percent the number which would be estimated from the tables based on model experiments.

It will be noticed that in addition to this more uniform turning moment all the conditions suggested in the paper referred to as likely to permit of the use of a higher thrust than 11¼ pounds, are present in the turbine propeller as now made. For example, the tips of the blades usually have much greater immersion than in the screws driven by piston engines, because of their small diameter; also the pitch ratio is very fine; and, lastly, the area is thrown as much as possible out towards the tips of the blades. I also pointed out some years ago ‡ that the thrust of propellers driven by four-cycle explosion engines should not exceed 8 to 9 pounds per square inch, because, unless a large number of cylinders are employed, the very irregular turning moment of these engines causes cavitation to occur at lower thrusts than in the case of double-acting steam engines. I refer to this because some criticism has lately been expressed concerning the accepted theory of cavitation, on the ground that it had been proved that some propellers would stand a higher thrust than 11¼ pounds without cavitating, and that some cavitated at a much lower thrust. It is a mistake to suppose that 11¼ pounds was intended to apply to all cases.

It has been suggested that the peripheral velocity of the propeller is a better criterion of the approach of cavitating conditions than thrust per unit area. I will give my reasons for not concurring with this view. The peripheral velocity at which cavitation commences is not by any means constant, but varies both with pitch ratio and "abscissa" value or slip ratio to a much greater extent than does thrust per square inch.

In Table I. are shown the cavitating speeds of three-bladed, turbine-driven propellers, having a developed area of 0.74 disc area, assuming a limiting thrust of 13 pounds per square inch of projected area.

In Table II. I give the peripheral velocities of the same screws at these cavitating speeds, and it will be seen that they vary from 4,800 to 17,280 feet per minute.

I have drawn a thick line round those figures in the table which lie within the limits of usual turbine practice; that is, I include pitch ratios lying between 0.8 and 1.0 and "abscissa" values lying between 9 and 13. Within these circumscribed limits the peripheral velocities only vary from 10,550 to 15,000 feet, and this probably explains why an impression has been formed that peripheral velocity is a safe guide in the design of turbine screws, an average value of about 12,000 feet being recommended. This corresponds with an "abscissa value" of 11 and a pitch ratio of from 0.9 to 1.0, which are about the conditions usually aimed at, and so far it would be correct to design for this tip speed, provided the developed area of the blade was about that given in the table. But if the blades are made wider than this, if, say, they have a projected area of 0.75 disc area instead of a developed area of 0.74 disc area, which latter is the area ratio used in Tables I. and II., then the peripheral velocities may be considerably increased.

In Table III. I have worked out the preipheral velocities for this projected surface ratio within the same limits of "abscissa

* Read at the Jubilee Meetings of the Institution of Naval Architects, July 6, 1911.

† Trans. I. N. A., Vol. XXXIX., p. 139.

‡ *Marine Propellers*, fifth edition, p. 58.

value" and pitch ratio. They range from 11,600 to 15,900 feet per minute.*

The peripheral velocity of the wing screws of the destroyer Tartar, which had this projected area ratio of 0.75 was 14,850 feet per minute. Very much lower velocities than these would have to be employed for propellers driven by geared turbines at lower revolutions, because, as will be seen from Table II., the permissible tip velocity decreases rapidly with increase of pitch ratio. On the other hand, a thrust of 13 to 14 pounds would be equally suitable for direct-driven or geared propellers.

Commander C. W. Dyson, U. S. N., in a very interesting series of papers containing a large amount of valuable information on the trials of United States warships which he has contributed to the proceedings of the American Society of Naval Engineers, states that thrusts as high as 16 pounds per square inch of projected surface have in certain cases been recorded in turbine propellers giving a fair amount of efficiency. This is so much higher a thrust than I have ever known to be put through a screw with good results that I think it possible Commander Dyson may have a different way of calculating the thrust. In any case, it is not exactly measurable, and depends on the estimate which is made of the value of the propulsive coefficient and of the thrust deduction. He also states that the thrust per unit of projected area does not appear to be so important as the thrust per unit of disc area in affecting efficiency. I think the explanation of the improvement in efficiency which he finds accompanying a reduced pressure per unit of disc area is that turbine propellers are nearly always made of too small a diameter for good efficiency in order to get high revolutions for the turbines, and the efficiency of the propeller would almost always be improved by increasing the diameter and reducing the revolutions, but at the expense of the combined efficiency of screw and turbine.

TABLE I.

Cavitating Speeds of Three-Bladed Screws, Assuming 13 Pounds Thrust per Square Inch and Developed Area = 0.74 Disc-Area.

Pitch Ratio.	Nautical Miles per Hour.					
0.8	42.7	36.1	30.7	26.1	22.7	19.7
0.9	43.6	36.8	31.4	26.7	23.1	20.2
1.0	44.5	37.5	32.0	27.3	23.6	20.7
1.1	45.4	38.2	32.6	27.8	24.1	21.1
1.2	46.2	38.9	33.2	28.3	24.5	21.4
1.3	46.8	39.5	33.7	28.7	24.9	21.7
1.4	47.4	40.0	34.2	29.0	25.2	22.0
1.5	48.0	40.5	34.6	29.4	25.5	22.2
1.6	48.5	40.9	35.0	29.7	25.8	22.4
1.7	49.0	41.3	35.3	30.0	26.0	22.5
1.8	49.3	41.6	35.5	30.2	26.2	22.7
1.9	49.6	41.9	35.7	30.3	26.3	22.8
2.0	49.9	42.1	35.8	30.5	26.4	23.0
2.1	50.1	42.2	36.0	30.7	26.6	23.1
2.2	50.2	42.2	36.2	30.8	26.7	23.3
2.3	50.3	42.5	36.3	31.0	26.9	23.4
2.4	50.5	42.7	36.5	31.2	27.0	23.5
2.5	50.6	42.8	36.6	31.4	27.0	23.5
	7	9	11	13	15	17

Abscissa Values.

Mr. D. W. Taylor,† in the book he has just published on "Speed and Power of Ships," contends that the accepted theory of cavitation is inadequate, and that tip velocity and shape of blade section are the prime factors involved. There is no doubt that both have a very important influence on cavitation, and especially the latter. Mr. Taylor is so competent an experimenter and so high an authority on all matters connected with propulsion, that one would hesitate to question any opinion he may express on any subject coming within the scope of tank inquiry, but it is well known that propellers cannot be made to cavitate in a tank under ordinary conditions,

* The assumptions made are 10 percent wake and 10 percent thrust deduction, 50 percent propulsive coefficient, 85 percent blade correction; proj. area = .75 disc area; thrust 13 pounds per square inch.

† Naval constructor, U. S. N.

TABLE II.

Tip Velocities in Feet per Minute at Cavitating Speeds of Three-Bladed Screws, Assuming 13 Pounds Thrust per Square Inch, and Developed Area = 0.74 Disc-Area.

Pitch Ratio.						
0.8	17,280	15,000	13,450	12,300	11,370	10,580
0.9	15,720	13,800	12,450	11,350	10,490	9,760
1.0	14,500	12,820	11,590	10,550	9,720	9,100
1.1	13,500	12,000	10,800	9,850	9,000	8,500
1.2	12,650	11,250	10,150	9,250	8,500	8,000
1.3	11,900	10,580	9,600	8,720	8,060	7,560
1.4	11,280	10,030	9,100	8,260	7,690	7,170
1.5	10,700	9,550	8,650	7,850	7,320	6,800
1.6	10,190	9,100	8,250	7,500	7,000	6,500
1.7	9,700	8,700	7,890	7,170	6,710	6,210
1.8	9,300	8,350	7,550	6,880	6,440	6,000
1.9	8,900	8,000	7,250	6,610	6,200	5,770
2.0	8,550	7,700	6,950	6,370	5,950	5,570
2.1	8,220	7,400	6,680	6,150	5,750	5,400
2.2	7,900	7,180	6,450	5,950	5,570	5,230
2.3	7,650	6,920	6,250	5,790	5,400	5,070
2.4	7,380	6,690	6,090	5,640	5,230	4,930
2.5	7,150	6,460	5,950	5,520	5,100	4,800
	7	9	11	13	15	17

Abscissa Values.

TABLE III.

Tip Velocities in Feet per Minute at Cavitating Speeds of Three-Bladed Screws, Assuming 13 Pounds Thrust per Square Inch and Projected Area = 0.75 Disc-Area.

Pitch Ratio.			
0.8	15,900	14,400	13,030
0.9	14,850	13,400	12,250
1.0	13,960	12,650	11,600
	9	11	13

Abscissa Values.

and very special means have to be taken to get the phenomenon to exihibit itself with model screws.

Mr. Parsons was able to observe it in a special tank with heated water having a vacuum over the surface, and it will be remembered that he confirmed generally the results I had obtained by calculation. Mr. Taylor has not followed this method, but has made experiments with a special form of blade which cavitates freely in cold water, and with the pressure of the atmosphere upon the surface, but the instrument he used could hardly be called a propeller, because it is far outside the limits of all existing practice. The pitch ratio is as fine as 0.3, and the blades are unusually narrow and thick. Now, even at 0.6 pitch ratio the efficiency of a propeller has dropped from a maximum of 0.74 to 0.58, and no propeller has ever been made, so far as I know, with so low a pitch ratio as 0.3, because under such conditions it is simply churning the water. This model cavitates so vigorously that the thrust becomes negative above a moderate number of revolutions, and if used as a propeller it would only need to be driven fast enough to actually reverse the direction of the motion of the vessel.

Cavities first begin to appear at as low a tip speed as 3,000 feet per minute, and the thrust becomes negative at a tip speed of between 5,000 and 6,000 feet. With this special "cavitator" Mr. Taylor has been able to measure the pressure at different parts of the face and back of the blade by means of a very ingenious arrangement of pressure gages, and he has found that there is a reduction of pressure at the leading edge of the driving face of his blade, and he expresses the opinion that cavitation is only injurious when it occurs at the driving face.

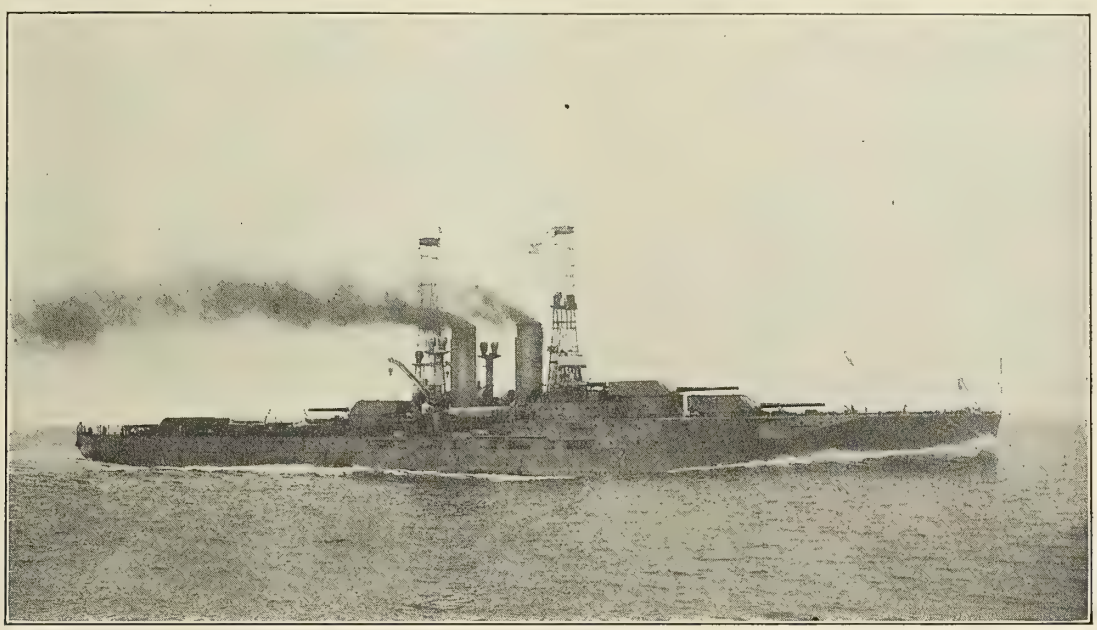
It seems to me that this conclusion has been arrived at somewhat hastily, and requires much further proof before it can be accepted. I think the reduction of pressure which was observed on the driving face was due to the abnormally fine pitch ratio in conjunction with a thick and narrow blade, and I do

not think it is possible for cavities to form on the driving face with ordinary pitch angles and blades of normal section.

The photographs taken by Mr. Parsons of his propeller when cavitating, under conditions properly representing those found in practice, show most clearly that the cavities are at the back of the blade. (See Fig. 2.)

I thoroughly agree with Mr. Taylor that it is of the utmost importance that the blades should be very thin at the leading edge, and it may even be advantageous to make the edge thinner than will stand the water pressure unsupported, and found it a very satisfactory method of fixing the blade area, and have seen no reason to doubt the soundness of the theory on which it is based.

I am glad to learn that Mr. Parsons is making a special tank of a much larger size than that with which he made his previous experiments, but arranged to work under the same conditions of hot water relieved of the atmospheric pressure, in which he will try models of actual propellers, and I think judgment should be reserved until the results he obtains are made known.



(Photograph by the New York Shipbuilding Company.)

UNITED STATES BATTLESHIP UTAH ON TRIAL TRIP.

to stiffen it with circumferential ribs as he recommends, but I do not think he has made out a case in favor of taking tip velocity as a criterion in preference to pressure, because he has himself shown that cavitation will under special circumstances begin at as low a velocity as 3,000 feet, and I have shown that in the case of the *Tartar* the tip velocity was as high as 14,850 feet with good results.

It will be observed that Mr. Taylor's cure for cavitation is the same as my own, namely, very wide blades, although he arrives at it by a different line of reasoning. He thinks that "face cavitation begins to spread slowly with increase of tip speed, so that the wider the blade the greater the area of the face whose thrust is not nullified by cavitation."

As already stated, I doubt the existence of face cavitation on a properly designed propeller, although it can evidently exist on an instrument specially designed to cavitate, and I still think that the great waste of power admittedly caused by cavitation is due to cavities at the back of the blade, and that these affect the efficiency, because at least half, and usually the major portion, of the thrust is due to the suction of the blade back, and this is lost as soon as the water breaks away from the back. Sir John Thornycroft has suggested to me that efficiency is also probably affected by the fact that when cavitating the propeller is working in a medium of less density, because the air bubbles extracted from the water forward of the screw form part of the stream passing through the screw's disc, as clearly shown by the spirals in the photographs (see Figs. 1 and 2), and thereby reduce its density.

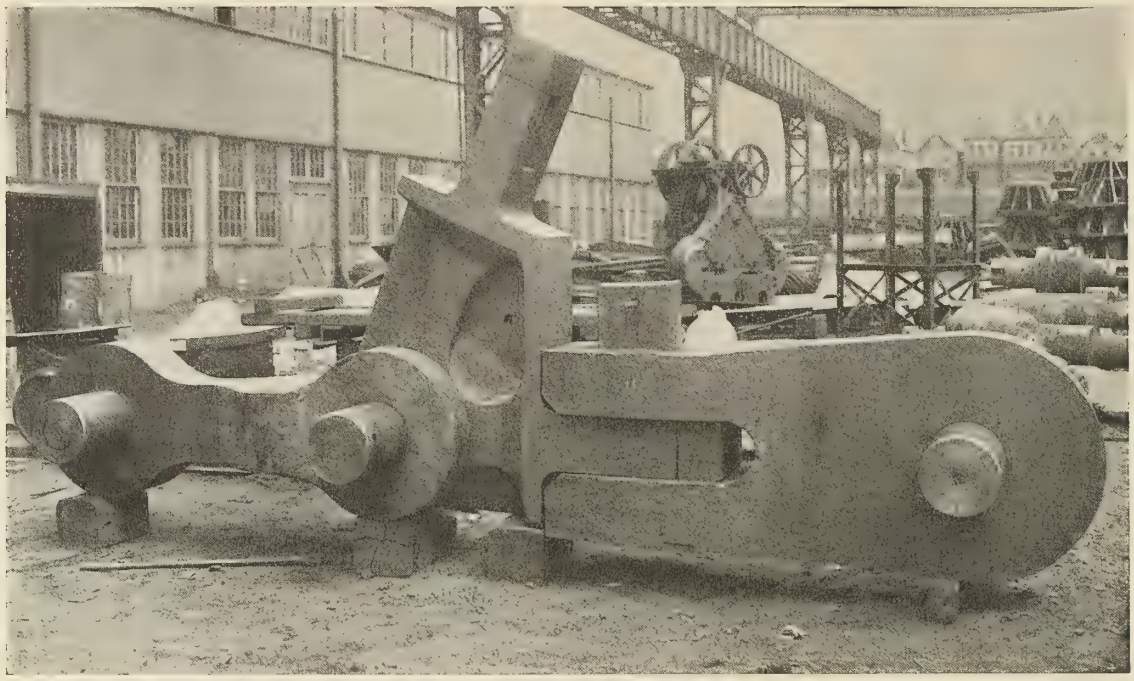
It may be objected that I bring forward no fresh proof that thrust is a safe guide, and that the tip velocities I have given in the tables are based on the assumption of a fixed limit of pressure. This is quite true, and perhaps further experiment only can settle the question. I must, however, say I have

Trials of the Utah.

The United States battleship *Utah* completed her official trial trips over the Rockland, Me., course on June 26. She is fitted with Parsons turbines, driving four shafts, and is a sister ship of the *Florida,* now building at the New York navy yard. Both of these ships are equipped with Babcock & Wilcox watertube boilers, fitted for burning both coal and oil. The *Utah* is about 98.5 percent finished, and is expected to go into commission in August.

On her maximum trial run she developed a speed of 21.63 knots, while the average speed during this run was 21.28 knots, when the turbines were running at 329.17 revolutions per minute. The contract speed for this ship is 20.75 knots, which was made on an average of 315 revolutions. The engines developed 28,477 horsepower at maximum speed. The standardization trials covered about twenty runs at average speeds of 10.55, 12.01, 16.8, 19.05 and 21.28 knots per hour. The trials were satisfactory and of great credit to the builders of the vessel, the New York Shipbuilding Company, Camden, N. J.

From the returns compiled by *Lloyd's Register of Shipping,* it appears that, excluding warships, there were 496 vessels of 1,476,394 tons gross under construction in the United Kingdom at the close of the quarter ended June 30, 1911. The tonnage now under construction is about 102,000 tons more than that which was in hand at the end of last quarter, and exceeds by 358,000 tons the tonnage building in June, 1910. The figures are the highest reported in the Society's Quarterly Returns, being 62,000 tons more than the previous record total, which was reached in September, 1901. The figures for June, 1909, have been practically doubled in the last two years.



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TYPE 3. For engine housings, engine bedplates, air compressor bedplates, air compressor framings, hand wheels, gears, rudder bearings, stuffing boxes, windlass gears, windlass drums, bearing brasses, bushings, spiral gears, port lights, air pumps, reducing valves, etc., etc.

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TYPE 7. For general hardware, quadrants, railings, name plates, indicators, hatches, grease cups, oil cups, gauges, stanchions, engine telegraphs, controller fittings, etc.

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1	71,000	28,500	32.0	27.8	1 Inch
2	65,400	28,400	38.5	31.1	1 Inch
3	65,100	34,400	18.5	17.2	1 Inch
4	56,900	22,800	57.5	43.7	1 Inch
5	59,500	22,000	52.0	37.6	1 Inch
6	51,100	18,100	65.0	45.3	1 Inch
7	59,200	23,000	50.0	39.1	1 Inch
8	32,000	17,500	21.0	18.8	1 Inch
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OUR PRESENT KNOWLEDGE OF THE VIBRATIO N PHENOMENA OF STEAMERS.*

BY KONSUL DR. O. SCHLICK.

In view of the apparent impossibility of dealing scientifically with the vibrations which made their appearance with more or less intensity in every steamer, these were, up to about the beginning of the eighties of last century, regarded as an unavoidable evil. With the gradual increase in the engine power and speeds of steamers, however, the cases in which the vibrations assumed an exceptionally violent form became more and more frequent, and greater attention began therefore to be given to this phenomenon. Twenty-seven years ago, at the spring meeting of the Institution of Naval Architects (1884), I had the honor of reading a paper "On the Vibration of Steam Vessels," and I believe this was the very first publication of an attempt to give a scientific explanation of vibration phenomena. The contents of this paper mainly consisted in the proof, then given for the first time, that vibrations were in no way caused by weakness of the hull of the vessel, but that they were chiefly produced by the inertia forces of the reciprocating parts of the machinery when these occurred at periods corresponding with those of the bending oscillations of the hull in the vertical plane. In this paper, therefore, the principles underlying the action of the inertia forces and the phenomenon of resonance were investigated.

In 1891 Mr. Yarrow conceived the happy idea of letting the engine of a torpedo boat run with the propeller shaft uncoupled, so that only the inertia forces exerted by the reciprocating parts of the machinery came into play. It became clearly evident that the vibrations which appeared had their origin in the synchronism of the inertia forces with the bending oscillations of the longitudinal axis of the vessel in her vertical middle-line plane. Further investigations led me to study the dissimilar behavior of the various types of engine met with in practice, and of the influence exercised by the position of an engine in a vessel, according as only vertically acting inertia forces, or tilting couples, or both of these together, came into play. Amongst other things the remarkable fact was established that the ordinary triple-expansion engine, in spite of the considerable exertion of vertical inertia forces and tilting couples which characterized it, was, under certain circumstances and when it was placed in a particular position in the vessel, harmless as regards the setting up of vibrations. I succeeded further in constructing a simple formula which made it possible to determine the number of the vibration-oscillations beforehand, and thus to avoid the critical number of revolutions in the first design of the engine.

As soon as it was recognized that means for the avoidance of the vibrations must be provided, not by the shipbuilder, but by the marine engineer, the efforts of the latter became directed to the destruction as far as possible of the action of the inertia forces, and the result of these was the invention of the balanced four-crank engines, which were proposed by me in 1894, and very speedily attained general adoption under the title of the "Yarrow, Schlick and Tweedy System." With the creation of the balanced reciprocating engine the first act in the solution of the vibration problem was in a manner brought to a conclusion. The extremely violent vibrations which are to be attributed to the action of the inertia forces of the reciprocating parts of the machinery can, with the exception of a small residue, always be avoided by correct balancing. After this short historical review I should like to proceed to show with what phenomena we have to reckon in vertical reciprocating engines. To this point I shall give very brief expression, as I am no doubt right in assuming that the more important of the matters entering into the discussion are well known.

If a single-screw steamer be equipped with an unbalanced vertical engine, there will in most cases arise (with a particular number of revolutions) vibrations, which consist in a bending of the longitudinal axis of the vessel in a vertical plane, in the course of which two nodes are formed. Thehe two-node vibrations are termed "vertical vibrations of the first order," and are said to be of single frequency. The latter expression is intended to convey the fact that the hull of the vessel makes a number of oscillations per minute exactly corresponding with the number of revolutions of the engine. If the revolutions per minute advance beyond the critical number the vibrations disappear, only to appear again in a violent form at a number which is generally less than twice as great. Three nodes now appear. This is called the "vertical vibration of the second order." The frequency, however, remains single, since the numbers of vibrations and revolutions coincide with each other here also. In very rapidly-running engines, indeed, vibrations of the third order with four nodes may also, in exceptional cases, be observed. So far as I am aware, the presence of vibrations of a still higher order has not been established with certainty.

Engines which develop only vertical mass forces, such as vertical engines with single cranks, provided they be placed exactly at node points and the critical number of revolutions be not considerably exceeded, so that no vibrations of a still higher order with more nodes situated at other points are set up, can never produce vertical vibrations. On the other hand, when engines of a description that produce tilting couples but no vertical forces are placed at a node point, they cause violent vibrations, provided they reach the critical number of revolutions belonging to the order of vibration in question. This is, for instance, the case with engines having three cranks set at 120 degrees with each other and having all moving parts of the same weight. Ordinary triple-expansion engines with three cranks set at angles of 120 degrees with each other and four-crank engines with cranks set at 90 degrees with each other, which produce vertical inertia forces as well as tilting couples and generally make the vessel vibrate very violently, can, strange to say, under certain circumstances remain quite passive.

The conditions under which this takes place are as follows: At the two extreme positions of the oscillating longitudinal axis of the vessel, tangents may be assumed to be drawn from the positions of the engines, which then intersect at a point a short distance behind the node belonging to the order of vibration in question. When the product of the weight of the vertically mass multiplied by the distance of the corresponding piston axis from the point of intersection of the tangents mentioned is the same for each cylinder, no vibrations will occur.

In the case of twin-screw vessels with pairs of exactly similar independent engines, interference phenomena will, as may readily be understood, be set up as a consequence of the vertical forces produced by them. If the reciprocating pistons of analogous cylinders be moved simultaneously in the same sense, the inertia forces thereby produced supplement each other, and very violent vertical vibrations ensue. Since, however, the two engines do not move with exactly equal speeds of revolution, the crank of the one will, after a little while, have forged ahead of that of the other by 180 degrees, and the two sets of inertia forces produced will then work simultaneously in opposite directions and thus counteract each other, so that the vertical vibrations will, for a short time, disappear. Since, however, the two engines are placed at a certain distance apart in the athwartship direction, the vertical inertia forces now acting in opposite directions form a couple

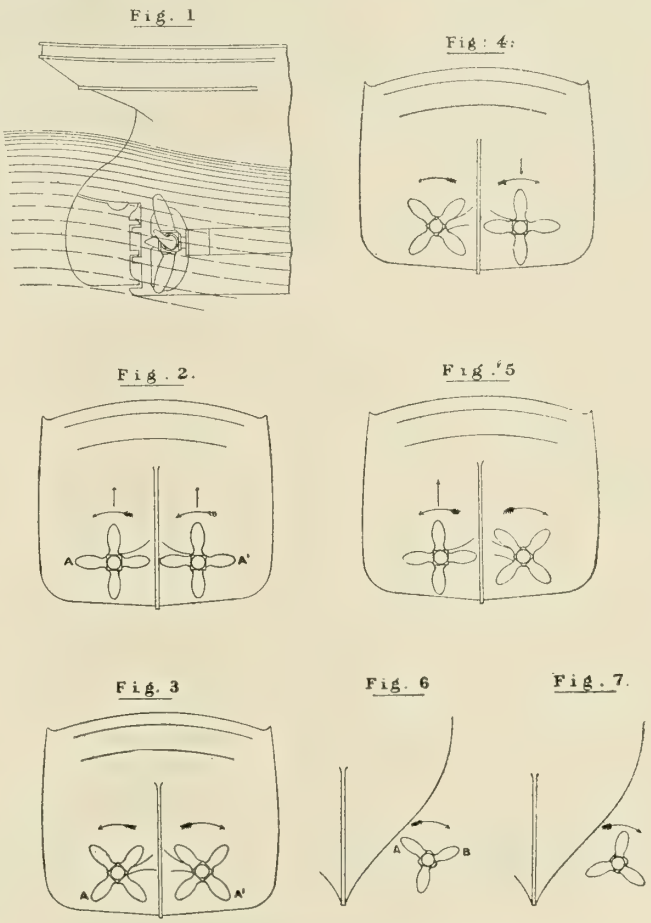
* Read at the Jubilee Meetings of the Institution of Naval Architects, July 5, 1911.

which give the section of the hull in way of the engines a lateral oscillation similar to that of the rolling motion of the vessel. These oscillations are communicated to the whole vessel in the form of torsional vibrations, and are of the single order of frequency of the number of revolutions per minute of the engine. When unbalanced engines are fitted in twin-screw vessels, periodically alternating vertical and torsional vibrations appear, and the period corresponds with the time in which one engine outstrips the other by a complete revolution. When correctly balanced engines are fitted, there is, of course, no further cause for the vertical and torsional vibrations of single frequency here illustrated. True, we shall see further on that both kinds of vibrations of higher frequency may notwithstanding be observed in a mild degree, and that weak vertical vibrations of single frequency also occur here and there.

As already mentioned, the vibration problem was in 1894 regarded as solved by the balanced reciprocating engine, and, indeed, as a matter of fact, vibrations of single frequency never occur in vessels equipped with these engines in anything like the degree formerly experienced. After the main evil was removed, however, it was found that weak tremors, which had formerly been masked by violent vibrations and thus escaped notice, were still present. The demands in regard to the quiet behavior of a steamer had become considerably greater, and I was now confronted with the question as to what might be the cause of these residuary vibrations, and how they could be removed.

In regard to the nature of these residuary vibrations, the following observations may be made. In most cases vertical vibrations (bendings of the longitudinal axis in the vertical plane) of frequency still showed themselves, though to a considerably less violent degree, and in twin-screw steamers they also occurred in periods. The appearance thus presented was that of the engine being still incompletely balanced. In addition, vibrations showed themselves, which, though of small amplitude, were still unpleasantly felt, because their frequency was very great—generally threefold and fourfold.

It cost me much time and trouble before I could determine the cause of these phenomena with certainty, and I owe large debts of gratitude to the Stettiner Maschinenbau Actien-Gesellschaft Vulcan, the Hamburg-Amerika Linie, and the Norddeutscher Lloyd for the ready willingness with which they allowed me to pursue these investigations, and for the obliging manner in which they lent assistance. In the first instance, the experiment was repeatedly made of allowing the engines of the large Atlantic liners of the companies named to run at their critical numbers of revolutions with their propellers uncoupled, and under these conditions not even the least suspicion of the vibrations otherwise experienced was felt. This proved conclusively that the residuary vibrations were not caused by defective balancing. The causes, then, had to be sought elsewhere. It would be going too far were I to describe here the exact manner in which I set about my experiments. I first sought, by the help of the pallograph, designed by myself, to determine in which positions of the cranks the maximum amplitude occurred which again should enable a conclusion to be come to as to the position in which the impulse reached its maximum, since the latter must always be a quarter of an oscillation in front of the maximum oscillation amplitude.* It very soon appeared that the vertical vibrations could not by any means be brought into fixed relation with a particular adjustment of the cranks. In the individual vessels the maximum amplitude occurred in connection with different positions of the cranks, and even in one and the same steamer the conditions changed as time went on. On the other hand, it became clearly aparent that the instant at which the ends of the vessel passed through the middle point of their upward swing, and therefore also the instant of maximum impulse, always coincided with that at which a particular blade of each propeller (the experiments were conducted almost exclusively with twin-screw vessels) assumed an almost exactly horizontal position, *i. e.*, when both were moving simultaneously downwards from the uppermost position.



DIAGRAMS SHOWING ACTION OF PROPELLERS CAUSING VIBRATION.

The assumption is here made that the propellers turn outwards, as it is generally expressed. When, on the other hand the blades in question stood at different angles, *i. e.*, when one of them pointed horizontally inwards, while the other pointed horizontally outwards—a case which occurs when one engine has forged ahead of the other by 180 degrees—the vertical vibrations of single frequency disappeared, or at any rate reached their minimum. While, then, one engine was advancing to a point a full revolution in front of the other, the vibrations diminished from a maximum to a minimum and then rose again to a maximum. The explanation of this phenomenon is that one blade of each of the two propellers meets with a greater tangential resistance than the others, and the cause of it is to be found in the very slight excess of pitch of the blade in question. The difference in the pitch is so small that it can rarely be detected by the help of the ordinary appliances ("pitchometer").

To understand this clearly we must picture to ourselves that the acceleration of the water by the propeller is already in

* The first experiments made in connection with these investigations were conducted by myself at the trial trip of the Atlantic liner *Deutschland*. I laid these before the Institution of Naval Architects in June, 1901, in my paper "On Some Experiments Made on Board the Atlantic Liner *Deutschland*" during her trial trip. In subsequent experiments the method was materially improved.

some degree imparted to it before the particles reach the leading edge of the blade. The angle at which the propeller blade cuts the threads of water flowing towards it (slip-angle) must therefore be a very small one—probably about 3 degrees. When the pitch angles of the different blades are not exactly the same, the one that has a very slightly greater pitch than the others has a considerably greater tangential resistance, while another one with smaller pitch may turn in the water almost without resistance, or, so to say, without load. While the blade with the greatest resistance moves, in the course of a revolution, from the upper position downwards, it imparts to the propeller shaft an upward pressure and endeavors to draw the after part of the vessel upwards, thus producing vertical vibrations of a period equal to that of the time of revolution of the engine; that is to say, vibrations of single frequency which are generally of the first order, and thus have two nodes. The occurrence of vertical vibrations of single frequency may thus, in vessels with balanced engines, be quite naturally explained.

Now, just as a difference in the pitch of the propeller blade may suffice to produce vibrations of single frequency in steamers with balanced engines, so also can a like difference destroy the vibrations of single frequency set up by the action of the inertia forces of an unbalanced engine when these two causes of vibration always act in senses contrary to each other and are approximately equal in their action. As I have already explained in detail in my paper of 1884, "On the Vibration of Steam Vessels," this may sometimes be easily attained by turning the propeller in coupling up the shafting in such a way as to make a different angle with the cranks.

The striking vibration phenomena which were observed on the occasion of the experimental trials with different angular positions of the cranks in H. M. S. *Terrible,* find their simple explanation in slight differences in the pitch of the propeller blades. That differences in the pitches of the individual blades may to a high degree be detrimental has long been known; but trifling ones of this kind, the very existence of which could scarcely be demonstrated, were not thought to have so much influence. But the result of these investigations also has the further effect that it clearly shows what great differences there are in the tangential pressures exerted by individual propeller blades, and, at the same time, in the stressing of the latter. The blade fractures which so frequently occur may thus find an explanation of the simplest kind. It is evident, also, from these considerations, how necessary it is, in all cases in which it is desired to avoid even the smallest vibrations of single frequency, and to obtain a specially good efficiency from the propeller, that the blades be machined, so that exact equality of these as regards both form and pitch is attained. When propeller blades are exactly adjusted the vibrations of single frequency disappear, provided always that the engines are correctly balanced; and since, by the help of the pallograph. every blade can be picked out which produces a tangential pressure differing from that of the rest, vibrations of single frequency can also be avoided in every case.

An attempt has also been made to connect the cause of vibrations of single frequency with inequalities in the turning moments. Theoretical investigations, however, have shown that the vibration-producing impulses of this kind do not suffice to produce the effects observed, and exact observations have shown this to be correct.

In all twin-screw steamers, again, an analysis of the diagrams drawn by the pallograph gives periodically-occurring vertical vibrations of fourfold or threefold frequency, according as the propeller has four blades or three. In steamers which were originally fitted with three-bladed propellers, and showed vertical vibrations of threefold frequency, these latter gave place to vibrations of fourfold frequency as soon as the three-bladed propellers were replaced by four-bladed ones.

The explanation of this phenomenon is as follows. The relative motion of the water flowing along the after body of the vessels does not take place exactly in the horizontal direction; but, on account of the large stern wave, it follows a sternwards rising curve, as shown in Fig. 1. In consequence of this each propeller blade meets with greater resistance when it has moved down from above till it is about horizontal; that is to say, when it has reached the position denoted by A and A_1, in Fig. 2, than when it is in the position opposed to this. Now, when the two four-bladed propellers simultaneously assume a position in which one of each of their blades points horizontally outwards, as shown in Fig. 2, an upward pressure is given to each propeller shaft. These two forces combine in endeavoring to raise the after body. Their magnitude diminishes considerably, however, when the two propellers have turned 45 degrees further round, and thus reached a position such as that shown in Fig. 3. This process is repeated four times for every revolution of the engine (or three times in the case of three-bladed propellers), and accordingly produces vertical vibrations of fourfold (or threefold) frequency.

When, in the cases of four-bladed propellers, one of the two engines has outstripped the other by an angle of 45 degrees, it follows that while one blade of the one propeller is pointing horizontally outwards, and thus assumes the position of greatest resistance, two outer blades of the other propeller form angles of 45 degrees with it, as shown in Fig. 4. The two inclined blades will then together exert a somewhat smaller upward pressure on the shaft than that of the horizontal blade of the other propeller. When both propellers have turned through a further angle of 45 degrees, the analogous forces again come into action, with the difference, however, that the two propellers have exchanged positions. In this manner there are produced during a single revolution eight upward impulses, which act on the after body of the vessel and accordingly produce vibrations of eightfold frequency, these being, it is true, generally of very small amplitude and scarcely discernible.

The upward impulse acts on the starboard and port sides alternately, as illustrated in Figs. 4 and 5, and, as may easily be seen, sets up at the same time torsional vibrations of fourfold frequency (threefold in case of three-bladed propellers). When, after a while, the one engine outstrips the other by 45 degrees more, the vertical vibrations of eightfold frequency disappear and give place to others of fourfold frequency; at the same time, however, the torsional vibrations also disappear, and so on till, with another advance, made by the one engine, of 45 degrees more, the game begins afresh. In this way the periodical increases and diminutions of the vibration phenomena may be explained. The results obtained during my long years of investigation have so often been confirmed by experience that not the slightest doubt can now be entertained as to their reliability.

In order to facilitate a general review of the subject, I shall once more briefly recapitulate the phenomena which occur in a modern twin-screw steamer equipped with correctly balanced engines. A steamer of this class generally shows periodically recurring vertical vibrations of single frequency arising from the defective pitch of one blade of each propeller. When the propellers are machined these vibrations disappear. Further phenomena take the form of vertical vibrations of frequencies, the number of which is in each case equal to that of the blades of one of the propellers, periodically alternating with other vibrations the frequencies of which are twice as great. Simultaneously with these last-mentioned vertical vibrations torsional vibrations occur of

frequencies equal in number to the blades of the propellers. Every twin-screw steamer shows torsional vibrations per minute *exactly equal in number to the product of the revolutions multiplied by the number of the blades of one of the propellers.*

If a single-screw steamer equipped with a correctly balanced engine be considered, vertical vibrations of single frequency will first make their appearance, when, by reason of defective pitch, one of the propeller blades shows greater tangential pressure than the others. A further characteristic is that of vertical vibrations of a frequency which corresponds with the number of the blades of the propeller, and in addition torsional vibrations, usually of considerable severity, occur, the frequency of which is likewise equal to the number of the blades. All these different vibrations, however, show no periodic increase and diminution such as are found to exist in the twin-screw steamers; their intensity remains constant.

The torsional vibrations of the single-screw steamers, however, are due to a different cause from that which operates in twin-screw steamers. In the case of the former. each propeller blade experiences the greatest resistance when it is in its upper vertical position or somewhat beyond this in the direction of rotation. The difference in the tangential pressure which the blade has to exert during a revolution is, in this case, considerably greater than in the case of the propeller of a twin-screw steamer. Since, however, the masses of the moving parts of the machinery, as in the case of a fly-wheel, seek to preserve a uniform speed of rotation, an increase of torsional stress will, each time that a blade passes the screw frame at the upper vertical position, be imparted to the shafting and thence to the engine seating, and will endeavor to incline the section of the vessel at the position occupied by the machinery in a sense opposed to that of the revolution of the propeller. In this manner an impulse is given which tends to produce torsional vibration.

In accordance with the foregoing, the torsional vibrations of single-screw vessels take their rise at the part of the vessel occupied by the engine and not at the after bearing of the propeller shaft, as in the case of the twin-screw steamers. This also explains the circumstance that torsional vibrations generally occur with considerable intensity in the fore body, while in twin-screw steamers they diminish gradually towards the fore body.

With the balancing of reciprocating engines, which came into fashion about the year 1894, everything that was possible was done for the removal of vibration, and the severe vertical vibrations formerly observed in unbalanced engines were, in fact, eliminated.

The periodical torsional vibrations of threefold or fourfold frequency occurring in the manner described above were still very unpleasantly felt, especially in swift passenger steamers. Although in the twin-screw steamers, which are principally dealt with here, they had their origin entirely in the propeller, and made their way into the fore body of the vessel, so that they made themselves felt very unpleasantly, especially in the saloon. Endeavors have, of course, been made to get rid of this evil, but these have been attended with only a comparatively small degree of success; for the only means at our disposal for the removal of these torsional vibrations consists in the prevention of resonance, or, in other words, in the avoidance of the critical number of impulses. The simplest means of attaining this end is the alteration of the number of the propeller blades, provided that, in view of other considerations, this appears permissible.

When a twin-screw steamer fitted with three-bladed propellers shows very severe torsional vibrations, the evil may in nearly every case be almost entirely removed when the propellers are replaced by others with four blades. On the other hand, I have observed that in the case of a very large steamer the vibrations almost entirely disappeared when, in deference to a proposal of mine, the four-bladed propellers were replaced by three-bladed ones. A measure of this kind, however, is sometimes attended by unpleasant secondary phenomena. For the altered frequency of impulse attained with an altered number of blades not infrequently coincides with the critical number of impulses for vertical vibrations of higher order. It then becomes possible to almost avoid the torsional vibrations, but their place is taken by vertical vibrations which are of threefold and fourfold frequency according to the number of blades borne by the propeller. These latter vibrations are, it is true, generally less unpleasant than the torsional ones.

In such a case, and when it is desired to avoid the expense of replacing the existing propellers by new ones with other numbers of blades, there is still another way which, it is true, only brings partial success, as a rule. It consists in the alteration of one of the propellers, assumed to be fitted with adjustable blades, by a modification of its pitch as compared with that of the other, so that at the normal speed of the vessel the one engine has the greater number of revolutions per minute by about 5 to 7 percent. The period within which the torsional vibrations advance to a maximum and return to a minimum again is by this means considerably shortened, and the vibrations never then attain the intensity experienced in the case in which the two engines work with almost exactly equal numbers of revolutions. This is explained by the circumstance that, under such conditions, the intensity of the impulse increases with great rapidity and reaches its maximum before the oscillating masses can be accelerated to such a degree that even an approximate approach can be made to the amplitude of oscillation which would be attained if the impulses had been continued with equal intensity for a considerable period of time.

The same principle underlies the endeavor to reduce the torsional vibrations of twin-screw vessels by giving four blades to the one propeller and three to the other. In some instances this method has been attended with appreciable success. It will probably be unnecessary to add that, in connection with the methods last described for diminishing the vibration, the speed of the vessel is always to some extent unfavorably affected.

With the introduction of the steam turbine the vibration phenomena entered into a new phase. Since, in the case of the turbine, every periodic action of the inertia forces in a direction at right angles to the longitudinal axis of the vessel becomes impossible, and since, further, the turning moment is completely uniform, all the disturbances which set up vibrations in the unbalanced reciprocating engine are entirely avoided. It was accordingly at first asserted, even by professional men. as an immense advantage of steam turbines, that they could not impart any vibration to vessels so engined. This view, to which frequent expression was at one time given, proved how little the vibration phenomena were understood at that time. The vibrations due to the propeller must, in turbine steamers, occur in a manner analogous to that in which they show themselves in steamers equipped with balanced reciprocating engines; but, by reason of the relatively very high speed of revolution of the propellers in these vessels, the frequency of their vibration per unit of time must be considerably higher.

For instance, if a three-bladed turbine propeller makes 200 revolutions per minute, and there are only two propeller shafts, 600 (or 1,200) vertical vibrations per minute will be set up, and these figures will increase to 800 (or 1,600) when the propellers are of the four-bladed description. The number of revolutions of 200, however, must be regarded as

almost the lower limit, and it is met with only in large steamers. In most cases from 400 to 500 revolutions per minute have to be reckoned with, and in such case frequencies of vibration up to about 1,500 to 3,000 per minute, or twenty-five to fifty oscillations per second, occur.

The amplitude of these vibrations, which are caused by the propeller alone, is, under like conditions, generally smaller in turbine steamers than in steamers with reciprocating engines, since in the former the work imparted during one revolution, and consequently also the vibration-producing impulse is less in inverse proportion to the relative numbers of the revolutions. The extremely high frequency of the vibrations of turbine steamers, however, involves great inconvenience to the passengers and crew and is a drawback for these vessels.

It is, on the other hand, a favorable factor that the unpleasant torsional vibrations do not extend over the whole length of the vessel, as they often do in steamers equipped with reciprocating engines. This phenomenon may be explained as follows: In theory the speed of transmission of the torsional oscillations of the longitudinal axis of a vessel is, for steamers of like types, the same. Now, when the frequency of the oscillation per unit of time is comparatively low, as, for instance, in vessels equipped with reciprocating engines, a few large waves will make their appearance in the longitudinal axis; that is to say, only a few nodes for the torsional vibrations will show themselves. If, on the other hand, the frequency be very high, as in the turbine steamers, a large number of small waves and a good many nodes will be formed. Now, since the assumption may fairly be made that, on account of damping action, the vibrations will cease after a certain number of oscillations, or, in other words, that, after reaching to a distance from their origin corresponding with a certain multiple of their wave-length, they will cease to be perceptible, the point at which the vibrations will no longer be unpleasantly felt will, in turbine vessels, be considerably nearer the after end of the hull than in steamers with reciprocating engines.

The use of torsion indicators to determine the horsepower developed by steam turbines has supplied a means for obtaining interesting information in regard to the fluctuations in the resistance to which the propeller blades are subject during a revolution. It may, for instance, be assumed that one of the outer propellers of a turbine steamer with three or four shafts is arranged as shown in Figs. 6 and 7, and that it has three blades. If the torsion angle of the shafting be measured at the instant at which the propeller is in the position illustrated in Fig. 6, *i. e.*, in which the tip of a blade is nearest to the skin of the vessel, a higher value is obtained than in the case in which the torsion angle is measured in the position shown in Fig. 7. This is explained by the circumstance that the tip of the blade lying nearest to the skin takes hold of the layer of water drawn along by the wetted surface in consequence of the forward motion of the vessel, and that the particles of water at this point move forward at a considerable speed. At this instant the blade in question meets with considerably greater resistance, and a greater twisting of the shaft must accordingly take place at the instant when the propeller assumes the position illustrated in Fig. 7, *i. e.*, when the tips of two blades are further removed from the skin of the vessel.

This increased resistance of a single blade acting unsymmetrically produces, somewhat in the manner already described, a one-sided pressure on the after bearing, which, together with the pressure exerted by the propeller on the shaft at the other side of the steamer, produces torsional vibrations. These vibrations occur with special vehemence because the distance apart of the two shafts, and therefore also the arm of the couple thus produced, is considerably greater than, for instance, in the case of twin-screw steamers.

Further, when it is realized that, in consequence of the large stern wave, the water flows to the propeller, not exactly in horizontal lines, but in a curve which rises somewhat in the sternward direction, it will be further evident that the direction of rotation is not a negligible matter in contributing to vibration. If a rotary motion in the outward direction be assumed, as indicated by the arrow in Fig. 6, the blade *A* will, for the reason alluded to above, experience in the first place an especially high degree of resistance in the position shown, and will in consequence exert a downward pressure. But in this position the blade *B* also meets with a greater tangential resistance, because it bears against the particles of water of the stern wave which are here curving upwards, and accordingly produces an upward axial pressure. The pressures produced radially to the shafts by the blades *A* and *B*, respectively, thus in part neutralize each other. If, on the other hand, the direction of rotation of the propeller be reversed, *i. e.*, the latter turn inwards, it will readily be seen that neutralizing of the radial pressures of the kind referred to does not take place, and the arrangement will in consequence be attended by vibrations of somewhat greater severity.

In turbine steamers there is an additional circumstance which tends to increase vibration. This is the inclination which usually has to be given to the propeller shaft, because, by reason of the large diameter of the turbine casings, their inboard ends usually lie considerably higher than in a vessel with reciprocating engines. As a result of this, the direction of motion of the water flowing towards the propellers makes a still greater angle with the axis of the latter than with which it already approaches them in the rising course of the stern-wave, and strong vibrations are set up in the manner already explained.

From what has been said, it will no doubt be clear that, for the removal or diminution of the vibrations in turbine steamers, in reality only one method remains, viz.: that of the prevention of resonance, or, in other words, of the avoidance of the critical number of revolutions for the vertical as well as for the torsional vibrations. A reliable prediction of these critical numbers of revolutions, such as that which my formula enabled me to make in steamers with reciprocating engines, has up to the present, unfortunately, not become possible. In particular the determination in advance of the critical number for the torsional vibrations still presents great difficulties. I have, indeed, busied myself for some time with this problem, but I am not yet sure whether I shall succeed in finding a practical solution of it.

In view of the high frequencies which occur in turbine steamers, one great difficulty lies in the circumstance that the critical frequency numbers for the successive orders of vibration lie comparatively near each other. It may, accordingly, very easily happen—in the case, for instance, in which the torsional vibrations are avoided by an alteration of the numbers of revolutions—that vertical vibrations make their appearance, and *vice versa*.

In the foregoing I have avoided all theoretical mathematical investigations, since they are of little or no value in actual practice and do not provide us with any serviceable means for the removal of the vibrations. What I have said here can only be regarded as a short abstract of the most important questions which have to be dealt with in connection with the vibration phenomena. Were a treatment of the whole question to be attempted it would probably occupy ten times as much space as the present paper.

Every one who is a member of the Society of Naval Architects and Marine Engineers will regret the ill health of the secretary and treasurer, Captain Baxter, and feel that his loss is a personal one.

THE RATIONAL APPLICATION OF TURBINES TO THE PROPULSION OF WARSHIPS.*

BY MONSIEUR A. C. E. RATEAU.

During the last ten years we have assisted at a considerable development of turbine engines in all navies. The success of these engines has been assured, because they are the only ones which enable us to solve the problem of speed, since the demand for high speed in every class of vessel increases daily. They have, however, other qualities which add considerably to the value of ships fitted with these engines. These qualities are principally endurance, the elimination of hull vibrations, economy of fuel at high speeds, and the fact that the engines are always ready and require no overhauling.

Great importance must have been attached to these qualities to justify the adoption of these engines, as they have the grave fault of showing a low efficiency at ordinary speeds, which reduces by one-half one of the principal factors of the naval value of ships, viz.: the radius of action.

This reduction in radius of action does not have the same importance for all naval powers. To Great Britain, whose wise policy has given her in all the seas of the world bases of supply not far distant from one another, endurance and constant readiness for action are qualities undoubtedly preferable to all others; consequently the British Admiralty adopted turbines as soon as they were available, and they can, even now, continue to use them without other inconvenience than the extension of the fuel supply and the improvement of the means of utilizing the same.

Other nations are not in the same position as regards turbines. They would have to provide in times of war the important convoys of supply, which, however well organized they may be, would form but an uncertain means of assistance, and would reduce the offensive naval war strength of the fleet by the number of the fighting units necessary for their protection. For these nations, therefore, the adoption of turbines has, far more than for Great Britain, meant increased expenditure, and they also have to suffer inconveniences of a strategical nature, which the greatest financial sacrifices can only reduce.

It is not surprising to find that some countries openly regret having followed the example of Great Britain, and that one of the most powerful of these is about to replace turbines by reciprocating engines for her new battleships. One may well hesitate to adopt such a radical course as to forego the advantages of turbines. Makers of turbines are, therefore, endeavoring to make these engines more economical at low speeds. The solution of the problem has been sought by making the propeller shafts revolve independently, so as to keep the turbines at a constant speed of rotation, thus securing a good efficiency; the transmitting gears are in such cases designed with toothed wheels or electric motors.

Even admitting that by the introduction of these means of transmission there will not be a considerable loss of efficiency, their employment will always entail a certain complication and weakness, and the machinery so designed will lose two qualities that are most highly appreciated, viz.: strength and simplicity.

In the present paper it is proposed to leave out of consideration these methods of transmission and to keep to the study of what may be done with steam engines only, turbines and piston engines. By suitably combining them, it appears possible to improve greatly upon the actual consumption of steam, especially at reduced speeds. Turbines are now as well understood as reciprocating engines. We know that from the point of view of efficiency their advantages are limited by certain conditions. The piston engine has, in fact, an excellent efficiency when the steam has a pressure of 15 to 30 pounds per square inch, but it becomes bad if the expansion is carried too far.

To utilize the expansion up to a pressure approaching those obtained in the condensers we must have cylinders of large dimensions, the attainment of which is impossible, and in which, moreover, friction losses and condensation would absorb the theoretical gain obtained by the increase of expansion. Turbines, on the contrary, have their best efficiency at low pressures, and are able to utilize the expansion beyond the condenser pressures; while they give rise to great losses at high pressures due to the friction of the revolving parts in the steam space, also to leakages through the clearances between the moving and stationary parts. Marine turbines are further restricted to low velocities, instead of being able to utilize those which are best for a good efficiency. It is obvious, therefore, that if we can have an arrangement of combined engines, arranged in series, in which the reciprocating engines utilize the energy of the steam only up to the limit of expansion suitable for a good efficiency, leaving to the turbine the duty of utilizing the expansion down to condenser pressures, we shall then have an engine much superior, whatever be the speed of the ship, to one consisting exclusively of turbines or reciprocating engines.

Ever since 1900 we had foreseen the necessity of a combination of the two kinds of engines. At the meeting of this institution of 1904* we described the arrangement installed, according to our ideas, by Messrs. Yarrow & Company on board a small torpedo boat. In this arrangement the reciprocating engines and the turbines were independent; by working the reciprocating engines only we could obtain very economical results at low speeds. But we must take account of the qualities as well as the faults of each engine; we have managed to gain some advantages, although we cannot eliminate all the faults.

In 1906 we fitted the French destroyer *Voltigeur* with an improved arrangement of engines. The power is distributed on three shafts (center shaft reciprocating engine, with turbines on wing shafts). The engines are so designed that when going at full power the distribution is equal on these shafts. Up to a speed of 20 knots the reciprocating engines exhaust into the turbines, but above this speed the engines become independent. We would, therefore, have realized a perfect engine up to a speed of 20 knots if the reciprocating engines and the turbines had been designed solely with the view to obtaining better results by working by stages; but, instead of this, they were designed more particularly with the object of obtaining the maximum efficiency at full power.

However this may be, the *Voltigeur* has undeniably demonstrated the superiority of the system; because below 20 knots the consumptions are slightly above those obtained in destroyers of the same class fitted with reciprocating engines. Above 20 knots, notwithstanding the presence of the reciprocating engines (which under such conditions are not advantageous), the consumptions remain less than those of all other destroyers even with turbines only. This is due to the superior efficiency obtained with multi-cellular turbines. See Figs. 1 and 4, showing the arrangement of machinery of the *Voltigeur*, and the comparative curves of consumption of the *Voltigeur, Chasseur* (with reaction turbines) and *Carabinier* (with reciprocating engines). In the author's opinion the best arrangement is the following:

COMBINED ENGINES FOR BATTLESHIPS AND CRUISERS.

The propulsive power is distributed on four shafts, each pair (port and starboard) being worked by an absolutely inde-

* Read at the Jubilee Meeting of the Institution of Naval Architects, July 5, 1911.

* Trans. I. N. A., Vol. XLVI., p. 168.

pendent set of engines. In each set a reciprocating engine drives the wing shaft and exhausts into a turbine which drives the inner shaft.

The reciprocating engines and the turbines are designed to develop a power equally distributed on the four shafts when running at maximum speed. At cruising speeds the reciprocating engines develop much more power than the turbines.

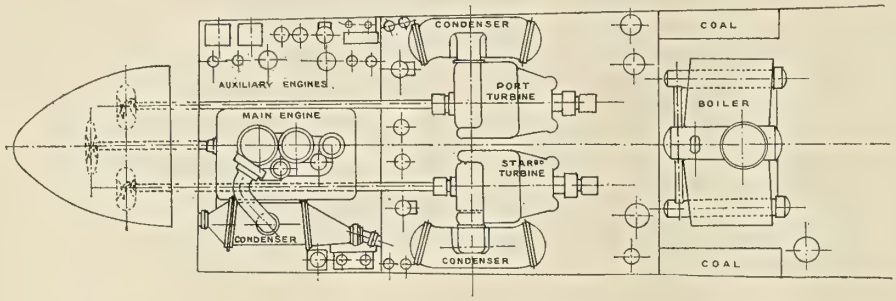


FIG. 1.—MACHINERY ARRANGEMENTS, DESTROYER VOLTIGEUR.

The reciprocating engines should naturally be able to run ahead and astern without engaging the turbines. This design includes an exhaust direct to the condenser; this exhaust opens at the moment when the normal exhaust to the turbines closes by means of two connected valves. These valves are operated automatically when starting, thus avoiding any error or loss of time. It appears unnecessary to introduce astern turbines

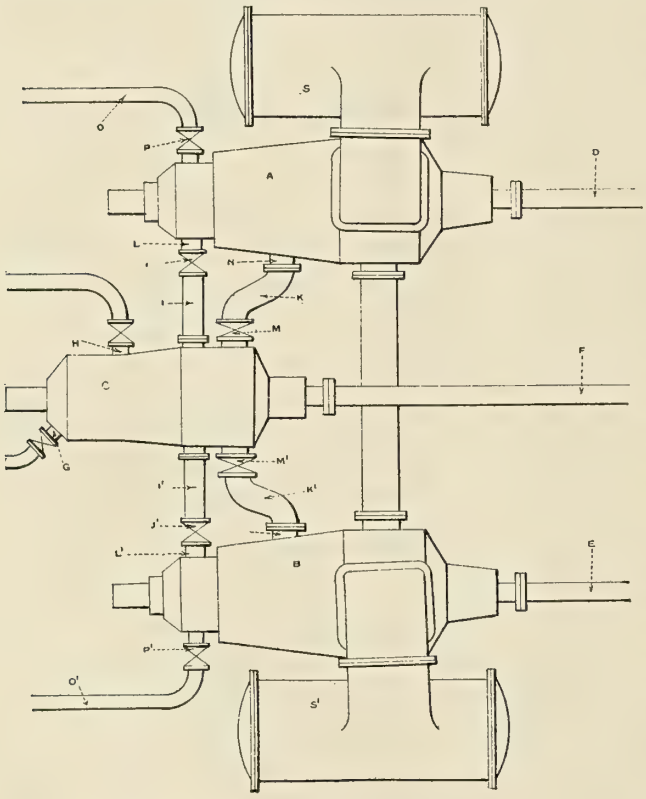


FIG. 2.—IN PRACTICE THE POSITION OF EACH TURBINE IS ARRANGED ACCORDING TO THE DISTRIBUTION OF BULKHEADS AND WEIGHTS.

on the center shafts, but this could be arranged without much difficulty.

With such an arrangement the following advantages are obtained:

(1) *Maximum Speed.*—For the same weight of machinery relatively to the propelling engines, there will be an increase of the maximum power from 15 percent to 20 percent, which corresponds to an increase of speed from 5 percent to 7 percent of the maximum speed, say 1 to 1.5 knots for battleships intended for 20 knots.

(2) *Cruising Speed.*—At this speed the consumption will probably be less than that of ships with reciprocating engines only, and it will not reach one-half of that with turbines. By comparison with the latter the radius of action will be doubled, or, if prefered, it may reduce the fuel supply in the same proportion.

(3) *Maneuvering.*—When maneuvering in port it will be found that the arrangement of wing shafts driven by the reciprocating engines is a more favorable one than that of vessels with two or three propellers driven by reciprocating engines only. When maneuvering in squadrons, stations will be as easily kept as by other ships, because the regulation of speed can be adjusted by the operation of the stop valve on the reciprocating engines.

ARRANGEMENTS OF TURBINES FOR SCOUTS AND DESTROYERS.

It will be readily understood that, although the distribution of the propelling machinery on four shafts does not present any inconvenience in large ships it is difficult to achieve in the scout and destroyer classes.

If it is intended to apply the combined system in these small vessels it will be necessary to adopt an arrangement with three shafts similar to that of the *Voltigeur,* in which, at certain speeds, the reciprocating engine on the center shaft will exhaust into the wing turbines; but, in order to retain sufficient maneuvering qualities, it will be necessary to put astern turbines on the wing shafts and a direct exhaust from the reciprocating engine to the condenser, so as to make this engine independent for maneuvering in harbor.

This arrangement may perhaps be thought complicated. To simplify it we may adopt the arrangement recently installed on the White Star Line vessels: two reciprocating engines driving the wing shafts and both exhausting into the same turbine, placed on the center shaft, and, when maneuvering, direct to the condenser. But the almost universal opinion is that it is wise to give up entirely the use of reciprocating engines for scouts and destroyers. These ships must be capable of developing at full power a considerable speed; they must therefore always be ready to pass from an ordinary cruising speed (14 to 16 knots) to very high speeds. On the other hand, the number of men composing the crew is limited through lack of accommodation, and it is necessary, without greatly reducing their offensive value, to limit to the strictest minimum the numbers of the engine and boiler room personnel.

The various conditions involve the use of engines and boilers of great flexibility and strength, and requiring the least manual effort; under these circumstances turbines and liquid fuel are essential. The difficulty is to have a good

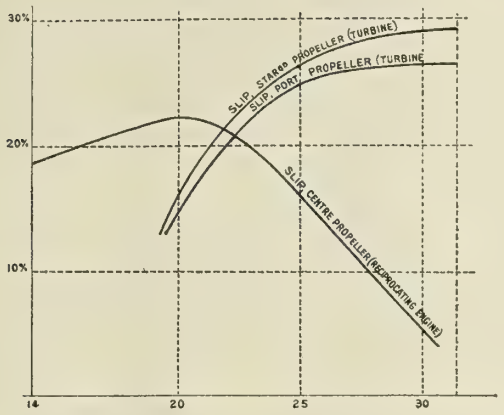


FIG. 3.—CURVES SHOWING THE SLIP OF THE PROPELLERS IN RELATION TO SPEED, DESTROYER VOLTIGEUR.

efficiency at ordinary cruising speeds. In order to overcome this the cruising turbine, which utilizes the expansion of the steam between the receiver pressure and the corresponding pressure at the exhaust into the high-pressure turbine, has been designed for the required speed. But the power developed by this cruising turbine being very small, it is not possible to make it work a propeller shaft by itself. It is, therefore, always placed on a shaft already driven by one of the main turbines. The result has been that the speed of rotation of this cruising turbine, which should be high in order to obtain a good efficiency, has been reduced by the speed of rotation of the main turbine, an obviously low speed, since it is proportional to that of the ship, and also because the cruising turbine does not come in except at moderate speeds of the ship. The efficiency, therefore, is always poor.

On the new French destroyers there are only two propelling shafts, each shaft being driven by an independent turbine, as has been the practice since 1898, when the torpedo boat *No.* 243 was used for experiments on the adoption of turbines for small ships. The results of these experiments were communicated by the author to this institution in 1904.

The old cruising turbines, high-pressure and low-pressure, have been fitted in the same casing, end to end, thus obtaining all the advantage of great simplicity; but it is evident that the "cruising" part of these large turbines cannot give better results than the cruising turbines of engines arranged in separate groups.

To avoid these inconveniences, and the use of toothed-wheel gears or electric motors, we have proposed the following arrangement, in which the high-pressure turbine maintains constantly at low vessel speeds a relatively high velocity of rotation and, in consequence, a higher efficiency:

ARRANGEMENT OF TURBINES.

The ship is propelled by three screws; each shaft is driven by a turbine; only the two wing turbines being arranged for going astern (see sketch, Fig. 2). The center turbine *C* is fitted with a steam inlet at the forward end *G* and with a by-pass *H*. The exhaust of the turbine *C* is connected with pipes *I, I'* to the inlets *L, L'* forward of the turbines *A* and *B*, and also by pipes *K, K'* to some points *N, N'* farther aft in

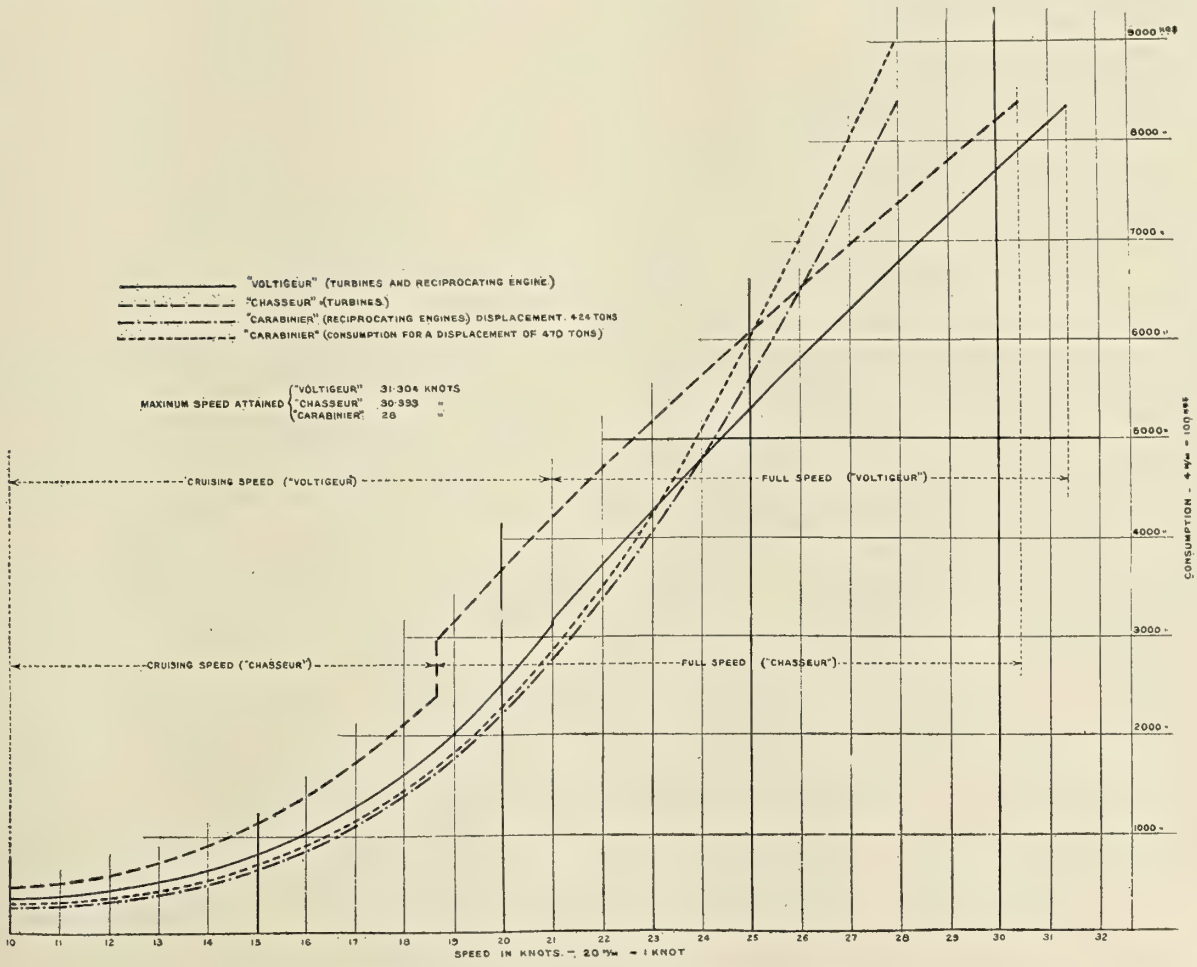

"VOLTIGEUR" (TURBINES AND RECIPROCATING ENGINE)
"CHASSEUR" (TURBINES)
"CARABINIER" (RECIPROCATING ENGINES) DISPLACEMENT. 424 TONS
"CARABINIER" (CONSUMPTION FOR A DISPLACEMENT OF 470 TONS)
MAXIMUM SPEED ATTAINED
"VOLTIGEUR" 31·304 KNOTS
"CHASSEUR" 30·393 "
"CARABINIER" 28 "
CRUISING SPEED ("VOLTIGEUR")
FULL SPEED ("VOLTIGEUR")
CRUISING SPEED ("CHASSEUR")
FULL SPEED ("CHASSEUR")
9000 kgs
8000
7000
6000
5000
4000
3000
2000
1000
CONSUMPTION - 4 ¾ = 10 000 kgs
10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
SPEED IN KNOTS. — 20 ¾ = 1 KNOT

FIG. 4.—COMPARATIVE COAL CONSUMPTIONS PER HOUR AT DIFFERENT SPEEDS.

the parts of the distributors of these turbines; these have, further, an inlet of live steam forward through the pipes *O*, *O'*. All these pipes are fitted with valves.

When cruising at 15 knots, for example, the valves *M*, *M'*, *P* and *P'* being shut, the turbine *C* receives steam through *G*, and exhausts into the forward end of the turbine *A* and *B*, which receives no other steam. If the speed has to be increased we open the by-pass *H*; the connections of the turbine *C* with *A* and *B* remaining the same. For higher speeds, steam will be admitted through *O* or *O'* into one of the turbines *A* or *B*, or both, if necessary; but to avoid having compression at the exhaust of the turbine *C*, the exhaust is let out forward at *N*, *N'* in the turbines *A* and *B*; when the valve *M* opens it must at the same time close the valve *J*. In these conditions the live steam, after having worked in the first wheels of the turbines *A* and *B*, mixes with the steam exhausting from *C*, and the whole works in the last wheels.*

Thanks to this arrangement the turbine *C* always works at great speed, but the power developed on the three shafts will not be equally distributed, as at low speeds the center shaft develops relatively more power than at high speeds. If, for example, the power produced at a moderate speed on the shaft *F* is 44 percent of the whole, and on each wing shaft *D* and *E* 28 percent, the proportion at high speed may become 16 percent on *F* and 42 percent on each shaft *D* and *E*. The variations of slip correspond to these variations of power.

At low speeds, nearly all the power being on the center shaft, the slip of its propeller is great, say from 25 percent to 30 percent, while the slip of the wing propellers is small. The conditions will remain similar so long as the live steam is admitted to the center turbine only. When live steam is admitted into the wing turbines the work produced by the center turbine increases very little, the increase of power being almost entirely due to the wing propellers. Their slip increases at the same time as that of the center screw decreases, and the speed of rotation of the latter rises far less quickly than that of the wing screws. The best results have thus been obtained, namely, that at ordinary cruising speed a center turbine does duty as a cruising turbine having a very high speed of rotation.

While cruising it is not necessary to have both condensers working. The exhaust of the turbines *A* and *B* can be advantageously connected by means of the pipe *T*, which is of ample section to maintain an even pressure between the two condensers. In this way, during a long run at low speed, we can economize the motive power necessary to work one of the sets of pumps.

The arrangement which has just been described is not more complicated than that which consists in putting two independent turbines on two shafts only. It has the advantage of being lighter and of entailing less steam consumption at cruising speeds. At high speeds it has the same advantages as the well-known systems of equally distributed power on three shafts, in which the center shaft is driven by a high-pressure turbine, and the wing shafts by low-pressure turbines, which do not receive any other steam than the exhaust of the high-pressure.

The maneuvering qualities of the ship are increased principally for horbor work, where a great advantage is gained by the action of the center propeller on the rudder; in fact, it is only necessary to steam ahead with the center propeller, while the others are maneuvering ahead or astern, and to join the exhaust of the turbine *C* with any point of the pipe *T*. This extension of maneuvering qualities is all the more important, as, with the increase in length of destroyers, it becomes more and more difficult for them to enter and moor in a harbor without the aid of tugs.

* This is exactly what happens in the Rateau land turbines, compound type, a great number of which are working in factories.

Necessity for Careful Design of Propellers.

In the above description we have purposely left out the question of propellers, which requires particular attention. It will not be inappropriate to conclude this paper by an account of the method of calculation for propellers in those two particular cases. We shall confine ourselves to describing the difficulties.

For the arrangement of turbines only it is not sufficient to make a design suitable for one speed only. If, for example, we are only requiring to have the best efficiency at high speed, where the three shafts have about the same number of revolutions, the same design for the three propellers may be adopted. At low speeds, on the other hand, the center turbine develops a power relatively greater than the others, and its propeller revolves faster than the wing ones; in order, therefore, to obtain a suitable efficiency for cruising speed, the center propeller, generally smaller than the others, must be very carefully designed.

In the case of the combination arrangement, with reciprocating engines and turbines, the former develop at low speeds relatively high in comparison to those developed by the turbines; this difference decreases in proportion to the increase of speed, and almost disappears at the maximum speed. The slip of the propellers of the reciprocating engines decreases when that of the turbines increases. In designing propellers these peculiarities must be taken into account, and also the difficulty of associating for the same work propellers whose pitches are very different.

The curves in Fig. 3 show the data obtained during the official trials of the *Voltigeur*, and they indicate the importance of the variation of slip. The slip of the propeller of the reciprocating engine increases up to a speed of 20 knots; because up to this speed nearly all the power is supplied by this engine, and also because of the influence of the stern wave, which on the measured mile where the trials were made became defined in the neighborhood of 24 knots.

Above 20 knots the turbines come into operation, and the slip of the propeller of the reciprocating engine decreases until it reaches a very small value at the maximum speed. Just the contrary happens with the slip of the wing propellers, which is zero at the start, and increases rapidly until it reaches 26 percent and 28 percent. Notwithstanding this relatively high value for the slip of the wing propellers at the maximum speed, the efficiency of the machinery remains good, as is shown by the excellent results obtained at the trials.

The *Voltigeur* has really obtained a speed of 31.4 knots, instead of 28 knots required by the contract specification.

Let us also point out the remarkable difference in the increase of slip of the wing propellers, although they are similar and symmetrical. This difference certainly arises in great part from the fact that the powers developed by the two wing turbines are not equal; also, because owing to the presence of the center screw, the stream lines of the water as it reaches the wing propellers are not symmetrical.

The trial of the Melville-McAlpin, Westinghouse reducing gear on the new naval collier built at Sparrows Point, Md., we understand, has been most satisfactory, and should this gear prove a success, which it is fair to suppose it will, the matter of providing large powers by means of internal-combustion engines will be greatly simplified and greater economy effected.

The naval collier *Neptune* has another feature which is well worthy of notice, and that is that the control of the turbines is in the hands of the officer of the bridge. We do not mean by this that the engine room force is done away with or it is reduced, but if the conditions are such that it is required to act quickly on the bridge as regards starting, stopping or reversing the turbine, it can be done, and, to our mind, this is a most advantageous feature and a commendable one.

PRACTICAL EXPERIENCES OF MARINE ENGINEERS.

Incidents Relating to the Design, Care and Handling of Marine Engines, Boilers and Auxiliaries; Breakdowns at Sea and Repairs.

Plotting Condenser Tubes.

When laying out condenser and water tubes this simple method for finding the hight of the equilateral triangle can be advantageously followed:

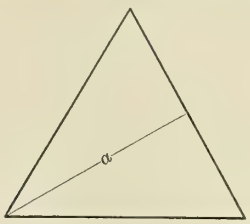
a = pitch of tubes x sin 60 degrees
= .866024 P
= say .866 P

which can be laid off on the slide rule very easily. In connection with this it may be proper to give the following table of standards, which accord very closely with general practice:

Diameterr	5/8	3/4	1
Area per foot of length	.164	.196	.2618
Pitch for composition tube sheets.	15/16	1 1/16	1 3/8
Pitch for cast iron tube sheets	1	1 1/8	1 1/2
Thickness of sheet	1	1 1/8	1 1/4
Total length of ferrule	15/16	15/16	15/16
Depth of lap	3/4	1 3/16	1
Number of threads per inch	16	16	16* / 14†
Outside diameter of tap	7/8	1	1 1/4* / 1 3/8†

* Commercial. † Commercial standard.

Tubes usually project 1/8 inch beyond the edge of the tube sheet. When circulating water has practically no pressure a



LAYOUT OF CONDENSER TUBES.

No. 20 gage tube can be used. When under 150-pound pressure No. 18 gage should be used, and when over 150 pounds pressure a No. 16 gage tube should be used. In estimating tube areas it is customary to consider the total length of the tube and to neglect intermediate space on the tube sheets. To correctly design condensers the calculation should be based on the amount of heat to be taken care of, temperature range and work in rate of transmission through cooling surface. But a very successful empirical rule is:

$$\frac{\text{pounds of steam to be condensed}}{10} = \text{cooling surface.}$$

For high-vacuum condensers this rule does not hold. The ordinary commercial cast iron condenser for small work usually sells for approximately $1 (4 shillings) per square foot of cooling surface.

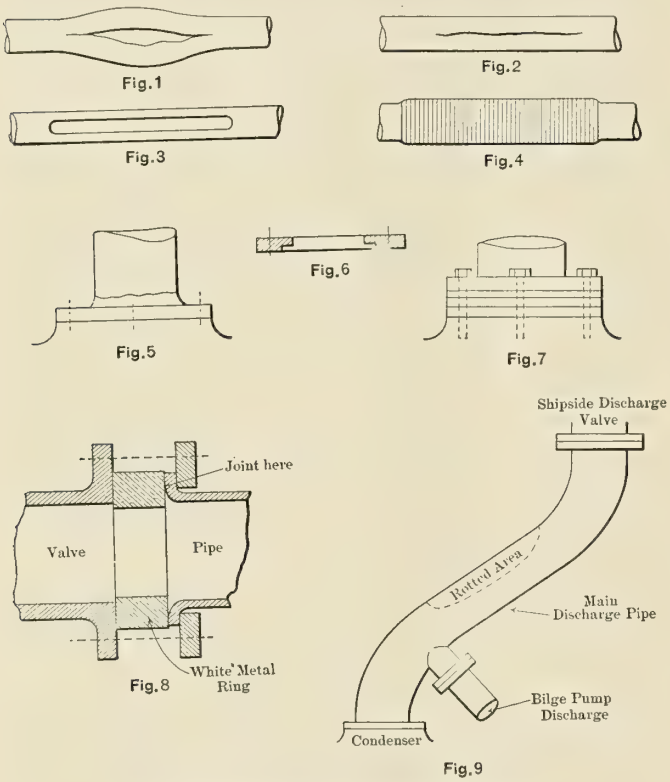
San Francisco. E. N. Percy.

Steam and Exhaust Pipe Work on Board Ship.

In marine engineering more than perhaps any other branch of application of steam, the importance of proper arrangements of pipe work and an adequate regard for strength of construction is distinctly felt. In the first place, should any defect occur while a vessel is at sea there is not only less opportunity for careful repair than in shore practice owing to the fact that engineering facilities are so limited, but any breakdown involves a very serious risk of further damage owing to the total or partial stoppage of the vessel, possibly in circumstances of extreme peril. Added to this, however, is the fact that the extreme economy of space which is necessary on board ship brings in its train two evils, one being that in many cases dangerous expedients are resorted to in order to crowd the pipe work into the narrow limits assigned to it, and the second is that, should any portion of the pipe work carrying steam at high-pressure fail, the risk to human life in such confined situations is a very serious matter. When, in addition to this, it is remembered that the constant pitching and rolling of the vessel puts a series of strains upon the pipe work connecting the various portions of its machinery which tends towards the breaking of joints or the fracture of the material of the pipe work, it is a very remarkable thing, which speaks highly for the care which is usually shown in construction, that so few serious accidents occur through the failure of pipe work in vessels while they are at sea. As, however, the price of safety is eternal vigilance, it may be useful to detail one or two breakdowns of steam and exhaust-pipe work which have occurred on ship board, together with their causes so far as can be ascertained, and the means that were adopted in order to effect either a temporary or permanent cure. The value of such an investigation will be that not only will sea-going engineers have some indication as to the parts of their pipe work which must be subjected to careful observation and may have one or two hints which may be new to them as regards the treatment of effects, but also the designer of marine plant may possibly benefit by a statement of the practical defects which have fallen to the lot of those who go down to the sea in ships.

One of the most common causes of trouble in steam-pipe work, and one which may lead to disaster of the most serious magnitude, is the splitting of the pipe to a greater or less extent along its length. This may be due either to an inherent defect in the pipe itself, or to its improper use while the vessel is in commission. As an instance of the first-mentioned cause may be taken a breakdown which occurred on a copper deck steam pipe. This pipe was very thin and the split was interesting from the fact that it did not occur upon a brazed pipe, as it was solid drawn. Owing, however, to the fact that upon one side of the tube it was rather too thin for safety, and also because the steam was suddenly turned on, thus giving full pressure to the pipe with a species of shock, the tube split at a bend, as shown in the sketch, Fig. 1. The action of the steam was intensified by the fact that steam had previously condensed in the pipe, and the water so formed had rushed along with the fresh steam, giving a water-hammer blow at the bend. The tube was too thin to allow of the usual clamp and joint to be placed upon it, so that it was repaired by first tapping the edges of the split together, as shown in the second illustration and then soldering upon it a Muntz metal patch of the shape shown in Fig. 3. This repair was then strengthened by winding a length of thin copper wire along the whole length of the patch and a little distance beyond on either side, the turns being placed close together, and finally the whole wire-bound arrangement was run up with solder as shown in Fig. 4. This method of repairing a split pipe is found to give a thoroughly satisfactory and permanent job if it is properly done, as it will not split again at that part under any ordinary circumstances.

The illustration of the second point, which was mentioned —that of palpably improper use—was a split which occurred on a winch steam pipe, owing to the fact that the pipes were left full of water in cold weather owing to an omission to open the drains when work was finished the previous night, and the winches run off. Next morning, when the steam was turned on somewhat too suddenly, the pipe split longitudinally over a distance of about eight inches. The repair was made by making three sets of semi-circular pieces of iron to the outside radius of the steam pipe, each set consisting of two similar pieces provided with end lugs. These were provided with bolt holes, and a piece of asbestos cloth, 10 inches long and wide enough to pass entirely round the steam piping, was covered with manganesite paste and placed over the split. In order to cover this cloth, two pieces of 1/16-inch sheet iron, 10 inches long, were bent to a semi-circle, so that when butted



TROUBLES WITH STEAM AND EXHAUST PIPES.

together over the asbestos they formed a complete shield. The clamps were placed over these and bolted together, forming a very tight and sound repair. In order to prevent any further occurrence of such trouble special care was taken to see that the winches were always run off and the drains left open when work was finished.

It may be as well here to interject a word of advice to young engineers. The above paragraphs will show the danger of steam pipes, particularly on deck, bursting owing to frost and to sudden admission of hot steam. If in cold weather an engineer makes a practice of running off the steam out of the pipes, winches and auxiliary machinery while the ship is in port, it will save many a cold morning's work in putting on clips, blank flanges and other repair accessories. As soon as work on deck is finished for the night all the winches and small machinery should be set running slowly and all drain cocks on both steam and exhaust pipes should be opened. The boiler stop valves should then be shut and the winches will go until the steam has run out of the pipes. The intermediate or deck stop valves should then be shut down, but care should be taken not to screw these down too tightly upon their seats, as there might be trouble in opening them on the following morning if a hard frost supervened. The winches and auxiliary plant stop valves should, however, be left open just as at the conclusion of work, in order that any condensed water can get out of the pipes through the drains.

Another very fruitful cause of trouble in steam-pipe work is, as mentioned previously, vibration, due to racking on the ship, and this often manifests itself in the "necking" of the pipe work; that is to say, the formation of a fracture all round the circumference of the pipe close up to one of its flanges. This is probably due to the fact that at such points the free vibration of the length of pipe imparted to it by shock to the boat is checked by a rigid resistance due to the increased diameter of the pipe work at the stiffening flange. Two cases of necking may, with advantage, be described, together with the means adopted to overcome the trouble. The first occurred on a ship which was running light and which met heavy seas, causing the engines to race. In this way the whole ship vibrated and the vibration caused the main discharge pipe to split right round its circumference close to the flange connecting the discharge pipe to the condenser, as shown in Fig. 5. The engines were, of course, stopped at once, and the pipe was sprung up a little by means of a block and tackle. When the joint between the flange and the condenser top had been broken, the broken piece of pipe remaining in the flange was taken out and a recess was cut in the bottom of the flange to a depth equal to the thickness of the pipe itself, and for a radial distance of about ½ inch, as shown in Fig. 6, outside the inner bore of the flange. The ragged edges were then filed off the pipe, and the flange was put on to the pipe with the recess downward and placed in such a position that the pipe stood through the flange for about half an inch. This protruding piece of pipe was next heated by means of a brazing lamp and tapped over gently with a hammer until it was flush into the recess. In order to make up the difference of a length between the pipe as it originally was, and that which it had after repair, three pieces of ½-inch plate, which was the only material available, were cut to the same size as the flange and drilled with holes having the same position as the holes in the flanges. The old studs were then drawn out and new studs were made of a sufficient length to go through the three pieces of plate and the flange. The whole arrangement was then assembled, as shown in Fig. 7, a joining of rubber insertion being placed between the flanges and all the plates. When this had been done the engines were started and the voyage was continued without any further mishap, the vibration being taken off the discharge pipe by means of securing it with blocks and tackle. At the conclusion of the voyage the repair had answered so well that nothing further was done to it except to fit hangers to the pipe in place of the block and tackle.

The other example of a necked pipe occurred on the main steam pipe of a coasting steamer. The cause of this was again vibration, due to the fact that the boiler and engine did not appear to be sufficiently stayed and the ship was running light. In this case the pipe was only broken half round its circumference close up to its flange and the means taken to make the repair were practically the same as those described above. The flange being cut off and cleaned out in order to allow the pipe to come through, this was then beaded over for a distance of about half an inch. It was not in this case, however, necessary to cut an annular recess in the flange, as a white metal ring was cast, about 1¼ inches thick, and having an outside diameter sufficiently small to fit inside the bolt circle. The inside diameter was made slightly smaller with the bore of the pipe. The face of this distance piece was then filed up and thin insertion joints were put on each side of the ring, and therefore between the valve and the flange of the pipe as

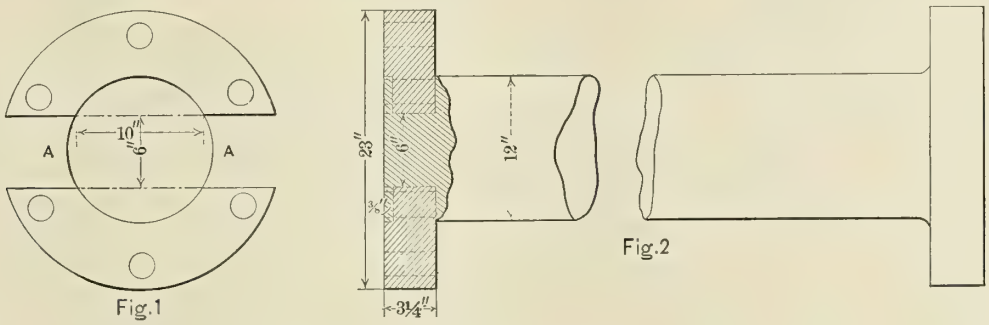
shown in Fig. 8. The whole arrangement was then drawn up tight with long bolts in the usual way, and this repair was sufficient to carry the boat home to port. It was rightly considered that the piping arrangement at this section was too rigid, inasmuch as the original pipe was practically straight. In order to give further freedom to the arrangement and to obviate any undue strain on the pipe work, due either to expansion and contraction, or to the shifting of the engine or boiler, a large expansion bend of the usual U-form was substituted and stays were also fitted to the engine in order to make it more rigid.

A very instructive breakdown upon a main discharge pipe may be recorded, inasmuch as it illustrates the danger of endeavoring to cut down the original cost of pipe work on board a vessel. In this instance, the main discharge pipe, which was made of copper, had a branch added to it for the purpose of accommodating the bilge pump discharge pipe, which was also made of copper. The object of this arrangement was probably in order to save the cost of a few yards of fairly small diameter copper piping and a ship side discharge valve, inasmuch as there was quite sufficient room for the bilge pump to have a discharge of its own; and, as a matter of fact, in the repairs following upon the occurrence to be described the bilge pump was given a separate discharge to the ship side. As a result of this first arrangement the main discharge pipe gave out while the ship was at sea along the portion marked "rotted area" in the sketch, Fig. 9. Inasmuch as the bilge pump sent all the oil, grease and other impurities through the main discharge, the acids contained in these substances attacked the copper of the pipe along the portion where they impinged most freely, and this trouble was not detected until the pipe entirely gave way. The engines, of course, had to be stopped, and upon examining the pipe it was found that nothing could be done to repair the pipe in the usual way by clamping Muntz metal sheets round it and interposing joining material, as the joint was far too weak. As a matter of fact, it was feared that it would collapse altogether. As, however, it was necessary to get the ship home again a temporary repair was effected in the following manner: First of all, long canvas bandages were made and sewn together so as to form a continuous band. This was then dipped into boiling Stockholm tar, and the bandage, while hot and sticky, was wound round the pipe not only over the rotten portion but over some little distance above and below it. The idea underlying this procedure was that the tar by setting hard upon the copper would tend to keep any loose parts together and in their place. The next step taken was to obtain some strong grain sacks, which were cut open and sewn round the pipe in such a manner as to form a loose envelope. This allowed sufficient space between the tarred lengths of canvas on the pipes and the covering envelope of sacking to allow of soft Portland cement being run into the space between them, the lower end of the sacking being, of course, lashed close to the pipe to prevent the cement from running out. The cement was thus worked round the pipe to a thickness of about 2 inches all round, and when this was set there seemed a possibility that an efficient repair had been effected. In order to make certain, however, rope was wound over the top of the previous work and the weight of the whole construction was suspended by means of a strong canvas sling and ropes from the roof of the engine room. When the cement was properly set the engines were started and the voyage was completed without any further mishap. The repair could only be considered a temporary one, inasmuch as when the pipe was stripped of its cement sheath it collapsed completely.

There is no doubt that a considerable amount of useful information of a practical character can be written concerning the behavior of pipe work at sea if space permitted, but the above examples are sufficient at the present time to show not only the very various causes of trouble to which such pipe work is subjected, but also to the ingenuity which is sometimes necessary in order to bring the vessel home to port under adverse conditions. From both these points of view, however, it is hoped that these notes are not without value.

Repairing a Broken Shaft.

I don't know what broke our intermediate length of shaft on the *Clara Belle;* but it broke, and we were towed into a West Indian port. I wanted to get a new shaft quickly, but there was little chance, I thought, but I found a length, which had been taken from some old steamer, which was an inch larger ours. The flanges were large, so we could drill new bolt holes all right. The worst was it was too long by 2 feet, but I had to do something, so I made the coupling shown in my sketch. Now what I want to know is, if my coupling is not as strong as my 11-inch shaft? I argue that, as the area of 11 inches is 95,033 square inches, I am as strong with the area of 10 by 6 inches, or 60 inches square, or really a little bit more, and I am backed up on each side with about 8½ inches of coupling, which coupling is bolted fast to its mate, and the three bolts hold each half up solid. Now how can this break down?



COUPLING FOR REPAIRING A BROKEN SHAFT.

I may say that when I got home they didn't take out the shaft and this is our third year. Some fellows think I should have brought the halves of the couplings together and not left the opening *A A,* and and I would have been stronger, but that would have cost a lot more.

Now, Mr. Editor, put it up to your readers, who know all about figuring strains (and then go and find out what some other chaps have done to make sure) and see what they have to say.

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Matters of Interest from the Jubilee Meeting of the Institution of Naval Architects.

The name of Schlick, Barnaby or Rateau on a paper is quite sufficient to assure that matters of importance will be most interestingly set before the engineer, and we give in this issue three papers by the above-named gentlemen as read at the Jubilee meeting of the Institution of Naval Architects, held in the early part of July in London.

Dr. Schlick's paper on the "Phenomena of Vibration of Steamers" finishes with the following: "I have avoided all theoretical mathematical investigations, since they are of little or no value in actual practice. * * * Were a treatment of the whole question to be attempted it would occupy ten times as much space as the present paper." We all should have been delighted if Dr. Schlick had given us ten times as much as he has, and certainly in his rather brief paper he has brought forward, in a most lucid manner, the causes for vibration in ships. We are surprised, indeed, to have him write as he does on mathematical investigations, as above all men he is qualified to speak on this subject with authority, and we are inclined to think that he belittles his own magnificent ability in this direction. Certainly practical results have followed his past mathematical efforts.

Mr. W. S. Barnaby, who is a member of the Council of the Institute, gave a paper on "Some Further Notes on Cavitation," in which he limits the thrust per square inch of projected surface of the propeller to about 11¼ pounds to prevent cavitation, that is under certain conditions, and he combats the idea that periphery velocity of a propeller is a better criterion than the thrust per unit area, and he considers that further experiment only can settle the question whether the thrust is not a safer guide than the tip velocity. Such experiments, he says, are being made under special conditions to settle the question. Mr. Barnaby draws attention to the advantages of the more uniform turning moment of turbines and that the irregular turning moment of four-cylinder engines brings the figures 11¼ down to 8 or 9 pounds per square inch. Here is a thought for those interested in internal-combustion engines.

Monsieur Rateau suggests certain arrangements of turbines in combination with reciprocating engines. He draws attention to the fact that the navies of the world could not all have their ships engined in like manner, as conditions demand, in some cases, a far greater radius of action than in others. We can hardly agree with Monsieur Rateau when he asserts that the turbines "are always ready and require no overhauling." He does not evidently like the new system which introduces mechanism between the prime mover and the propeller shaft, whether it be a geared or an electric reduction. He proposes to put the reciprocating engines on the wing shafts with the idea that in maneuvering they are more advantageous. This would simplify the turbines by not demanding any reverse rotor. He points out the advantages of the steam turbine under certain conditions and the advantage of the reciprocating engines under others, and decides that their combination is the one which should be used, with the exception of the scouts and the destroyers. In speaking of reduction gear, Sir C. A. Parsons considered the floating cradle not a good thing, stating that all that was needed was end play in the pinions.

In the discussion of turbines for warships, Admiral H. I. Cone, U. S. N., in his usual direct way, wanted to know whether the expediency of a combination of reciprocating engine and turbine warranted the introduction of the extra difficulties? Mr. A. E. Seaton, in speaking of the turbines, admired the tenacity of purpose of turbine builders. If it had not been for this, he asserted that it might have been laughed out of existence, as have other appliances, but he was very much in favor of the turbine because he thought it was the best means of fighting the internal-combustion engine.

Other papers presented at the meeting we hope to give later.

LEGAL DECISIONS REGARDING MARINE WORK.

Lien for Repairs in Foreign Port.

Although a charter party contains a provision that repairs shall be made at the expense of the charterers, a repairer who makes repairs on a vessel in a foreign port under a contract with the charterers, but confirmed by the master and with the knowledge of the managing owner of the vessel, is entitled to a lien if the provision was not known to him and he was not notified of it.—*The O. H. Vessels, Circuit Court of Appeals, Third Circuit.*

Collision Between Steamships.

Cross suits for collision were brought by the owners of the steamships *Aurelia* and *Umatilla*. The collision occurred in the daytime in the bay about 2,000 feet from the San Francisco piers. The *Umatilla* had backed from her pier to go out, and when 1,000 feet off gave a passing signal of two whistles to the *Aurelia*, which was in sight inward bound for Oakland. The *Aurelia* answered the signal, but the *Umatilla* continued to back for two or three minutes at full speed without giving any signal of the fact. The *Aurelia* did not materially change her course until the vessels were too close together to avoid collision. Both vessels were held to be in fault, the *Umatilla* for failing to give the proper signal to show that her engine was going full speed astern, and the *Aurelia* for failing to keep a proper lookout, which would have enabled her to avoid a collision, notwithstanding the *Umatilla's* fault.—*The Aurelia, District Court, U. S. California.*

Passing of Title of Vessels to Government as Constructed—Government Contracts Construed.

A corporation entered into a contract with the United States for a sea-going suction dredge, a revenue cutter and a cruiser. Certain creditors filed a bill in the Virginia Chancery Court asserting liens under the supply lien law of the State, averring the insolvency of the contracting corporation and asking for a receiver, which was made. He took possession. On final appeal to the Supreme Court of Appeals of Virginia it held the supply liens superior to any claim of the government. In the case of the dredge two of the five judges dissented, holding that the title to the dredge had passed to the United States.

The case came before the Supreme Court of the United States on writ of error, and the judgment was reversed as to the dredge and affirmed as to the revenue cutter and the cruiser. Section 211 of the specification for the dredge provided that the parts of the vessel paid for under the system of partial payments should become the property of the United States. Section 212 provided for insurance against fire and marine risks at the contractor's cost to the amount of each partial payment.

The government contended that the vessel was to become the property of the United States as fast as it was paid for. This view the court upheld. The fact that a government inspector had the power to reject or approve the materials did not of itself work the transfer of the title of a vessel. But if the contract express the intention that the builder shall sell and the purchaser shall buy the ship before its completion, and this purpose is expressed in the contract, it is binding, and the title passes. A contention that Section 212 did not show an intention to protect the title transferred to the government, but that the insurance was required for the government's security

It was held that this provision was not inconsistent with Section 211. Nor was it found inconsistent that bond was taken for the performance of the contract. A provision that the contractor was to be responsible for and pay all liabilities for labor and material incurred in the prosecution of the work was not inconsistent with the passing of the title in parts as paid for.

The question then was the right of a State lien law to fasten upon the property of the United States. It was held that the property of the United States could not be seized or encumbered under State lien laws. The dredge, as fast as constructed, became one of the instrumentalities of the government, and could not be seized under State laws to answer the claim of a private person.

In the case of the revenue cutter there was no such stipulation as to passing of the title on partial payments. The Secretary of the Treasury was authorized to make partial payments, and a lien was reserved on account of such payments by a joint resolution of Congress of May 5, 1894, which law was to apply to future contracts for vessels for the Treasury Department. The government contended that this resolution made a statutory lien by authority of the United States. But the Supreme Court did not agree to that contention. A bond was given by the contractor for the proper construction of the vessel, which provided that the contractor should promptly make payments to other persons supplying labor and materials. The court held that this requirement was a distinct recognition on the part of the government that the contractor might become indebted to other persons who might become entitled to liens upon the property.

The case of the cruiser was held to be controlled by the same principles as that of the revenue cutter. In that contract there was no provision for taking title to the vessel; it was stipulated that, on certain conditions, the title should vest in the United States as collateral security, and a clause of the contract provided for the release of liens before partial payments should be required. The court held that this contract also was made in recognition of the rights of those who should furnish work or materials for the vessel to secure their claims by liens which it was made the duty of the contractor to provide for in order to protect the title of the United States. —*United States v. Ansonia Brass & Copper Company et al., United States Supreme Court.*

Salvage—Question of Danger Through Breaking of Intermediate Valve.

In an action on behalf of three Humber tugs for alleged salvage services to a steamship, it appeared that the vessel was driven up more to the northward than her course should have been, and she missed the Spurn light. On the question as to whether the steamship was ever in any danger the evidence showed that when the engines were stopped, and before the vessel anchored, the engineer ascertained that the main engine valve was broken. He sent up information to the bridge, and subsequently went up himself. The chief engineer was a very capable engineer and a good and reliable witness, and according to his evidence the ship was never in any danger at all by reason of what had happened to the valve. He said he could work the engines by means of the main boiler valve without difficulty, and that it made a difference of not more than half a minute between moving the engines by means of the main boiler valve and moving them by the main engine valve. He said there was never any hitch and never more than a quarter to half a minute's interval between receiving and executing an order. That information was before the captain. It was held that the steamship had not been in any danger, and judgment was given for the defendants.—*The Calyx, 27 Times L. R.*, 166.

COMMUNICATION.

More Remarks on Cargo Loading.

Editor International Marine Engineering:

In reading International Marine Engineering for June, all interested in the subject of loading and unloading vessels must be set thinking, and the subject is one of vital importance, but it is not one on which data are readily obtained.

I am assured that in England the cost of a 40-foot vertical lift, coupled with a swing of 100 degrees and lowering, costs a little under 2 cents a ton of 2,240 pounds, which is about a penny. This cost covers the power and the man to handle the boiler and hoist, but does not include any handling on the ship or on the dock. It is, so to speak, the mechanical power cost. It is difficult to get even a moderately correct idea of the cost of moving a ton from its position in the hold to the hatchway, as obstructions intervene at times, and at very best the working conditions are disadvantageous. We should say that a 40-foot move horizontally would be about the maximum in an ordinary freight ship, and that two men could move a ton 40 feet in ten minutes with the usual ship appliances. If this time is taken as reasonably correct, the cost would be about 12 cents, or 6 pence, or about six times as much as the vertical hoist, which bears out Mr. Forbes' assertion of the economy of the vertical lift, as referred to in the article by him.

Handling freight is a good deal like many other operations, as, for instance, work in a machine shop, the time getting ready to do something often outruns that occupied in actual work, so in getting the cargoes out of vessels there is an unreasonable loss in moving cargo into a position to hoist.

Mr. Crane gets at an "obstruction" in referring to old captains and favored shipbuilders, but I do not quite agree with him as to some one having to pay for the new design. It is, of course, true that a set of blue prints costs a lot less than a set of drawings and tracings, but Mr. Crane, as a recognized designer, could, I feel sure, suggest to many of his clients changes the cost of which would be only on the designing side, and such cost would be made up by the advantages gained. Here is an opportunity where such a good helmsman as Mr. Crane could steer his clients on a better course.

When Mr. Harding advocates larger side ports I think he is considering in general a less satisfactory solution than larger or more hatches. He clearly shows how this question of modified design in freight steamers is not being acted upon, even with the knowledge of what such modifications would result in in a money-saving way. He makes a most practical and very wise suggestion that naval architects should spend, not a few hours on board a ship or in the freight house, but a week, from morning to evening, and then he thinks something would be done, and there is no doubt of this, that something would be done by the naval architect if he had to continue to work under the present conditions of loading and unloading vessels and unloading the freight on the docks. In Mr. Du Bosque's remarks he brings forward a most important point; that of being able to pick up the packages or sling them without injury. Here is one of the small details to which he calls attention, and they are of the utmost importance. No one knows this better than a man who has had Mr. Du Bosque's training and experience. The detail is, in fact, the all-important point. The best and most convenient hoisting apparatus in the world, even if it were run most economically, would be absolutely valueless if in its use the goods were injured.

Mr. Dickey draws attention to the classification companies' rigid demands as regards side ports, and even if they were provided we come up again against the horizontal movement or the vertical hoist question. If Mr. Dickey got a free hand I think his two-story shed idea would be worked out into something good. The suggestion of the "Naval Architect" as to crew's quarters is excellent, but the most important statement he makes is that there is no reason why the whole upper deck along the central line should not be open hatches. If this is so, and knowing who the "Architect" is I have no doubt of it, it is evident that something can be done at comparatively small cost, in better design.

Mr. Waterman calls attention to the diversity of cargoes. Of course, this counts much in the way of costs, as a certain amount of sorting has to be done at both ends of the route; but he points out that nothing new or novel is needed in the way of conveyors and other devices for handling freight, as there are now on the market some most reliable and practical devices to be had for the paying, and here seems to be just the point on which matters stick; that is to say, on the paying. I call attention to the lack of tact shown by some who have articles for sale, which, if installed, would be advantageous, and which customers are ready to put in, but they have been frightened off by the salesman who is unacquainted with the shipping business. In the case I have in mind the salesman wanted to have both the docks and the vessels handed over to him for a matter of two or three weeks, which, of course, could not be considered; therefore nothing was done.

Now we are crying out against high prices and howling still louder for our dividends, and shipping people are not having the easiest time in the world to make the dividends so much desired.

In some cases I have known that a certain class of freight, principally fruit, formerly shipped by water, is now going "all-rail," because of rough handling in stowing aboard ship doing so much damage that the value of the freight dropped to an extent that it paid to consider a more expensive means of transportation. Now in such cases is it not possible to have crates, specially designed, to be swung onto the ship in bulk? True, these crates would cost money, but if the design was properly considered I think, even with the disadvantage that probably most of the crates would be returned emptied, the system could be employed advantageously, as the sorting of articles at one end of the route for a customer would probably be done only once, or various shipments to a single consignee could be sorted and, so to speak, bulk crated.

Let us hope that this very interesting subject will be responded to by many of the readers of International Marine Engineering, whose experience certainly has been such as to place them in possession of facts, and a full discussion should result in a better understanding of the subject and lead to better methods.

Onlooker.

PERSONAL.

Mr. L. D. Mosley was appointed on June 20 chief engineer of the Metropolitan Steamship Company, with headquarters at Boston, Mass. Mr. Mosley's well-deserved promotion will be a matter of pleasure to his friends, as he has been at various times chief engineer of the finest passenger steamships on the North Atlantic coast, including the fast turbine steamers *Harvard* and *Yale*.

The Westinghouse low-pressure turbine, wherein the steam pressures are exactly balanced, thus obviating the use of dummy rings. is a modification in turbine design which certainly makes toward simplicity and economy.

TECHNICAL PUBLICATIONS.

Steam Turbines. By Joseph Wickham Roe, M. E. Size, 6½ by 9½ inches. Pages, 137. Illustrations, 77. Numerous tables. New York-London: McGraw-Hill Book Company. Price, $2.

Professor Roe offers this work on steam turbines to the student, whether at a school of engineering or in the engine room. It is concise, but the information given can be supplemented, as the Professor has adopted the excellent method of giving references, which are generally available. At the end of each chapter details of construction of various makes of turbines are shown. It is, of course, supposed that the student is somewhat versed in mathematics, but if he is not, he will not regret buying the work, as there is much explained therein which requires no mathematics whatever.

Gas Engines. By W. J. Marshall and Capt. H. R. Sankey, R. E. Size, 6 by 8½ inches. Pages, 278. Illustrations, 127. Price, $2.00.

We hardly believed it possible that there was room for another book on gas engines, but after reading the results of the labor of Messrs. Marshall and Sankey we feel that a very valuable addition has been made to the literature concerning what is at times a very provoking prime mover, and to those who study this work many of the provoking actions of a gas engine will become things of the past. "Mysterious action" is only a very easy name for pure ignorance, and there seems to be a determined resentment to thoroughly understand gas engines, and one would believe they take more satisfaction in guessing at what is the trouble than understanding its cause. The illustrations in the book are most admirably clear, and we recommend it with confidence to all who have anything to do with internal-combustion motors.

Power. By Charles E. Lucke, Ph. D. Size, 5½ by 8 inches. Pages, 304. Illustrations, 223. New York, 1911: Lemcke & Buechner. Price, $2.00.

Professor Lucke's book is an admirable one for every student to read at the very outset of his engineering studies. In a most pleasing manner the reader is carried from the past into the present concerning prime movers, and the way is paved for more minute and exact study of the various power producers. If the student could understand everything which is written by the Professor he would have lost his right to the name and have become an engineer, but where the work seems especially valuable in our eyes is in the admirable way in which it awakens in the reader a desire for further knowledge, and certainly such a sentiment is the desire of every instructor, and we are glad to know that such a book is obtainable, and we advise even those who are not engineers, but interested in the subject, to read it, as they will be thoroughly well repaid.

Directory of Shipowners, Shipbuilders and Marine Engineers, 1911. 813 pages. The Directory Publishing Company, Ltd., 15 Farringdon avenue, London, England. Price, 10s.

This valuable directory has gained much in its ninth passage through the press, and the new edition, which has been thoroughly revised and brought up to date, has gained some twenty pages. The utility of the book is beyond question to all who are associated with shipbuilding and shipping, as it enables instant reference to the vessels of the various owners and also to the *personnel* of the marine world.

In a large number of cases in the current edition the following particulars relating to boats have been added: Cubic capacity of holds and bunkers, loaded draft on summer freeboard and year when built. It is the intention of the publishers to insert these additional particulars against all boats in future. A list of marine engineers and naval architects, with their telegraphic addresses and telephone numbers, has also been included.

The Naval Annual, 1911. Edited by T. A. Brassey, A. N. N. A. Size, 6 by 9½ inches. Pages, 472. Numerous illustrations. London, W. C., 1911. J. Griffin & Company.

The Naval Annual, 1911, edited by Lord Brassey, G. C. B., gives information which shows the progress of the world's navies during the past year and much detail of construction, but, of course, in navy affairs exact details are always difficult to obtain, and often quite impossible for obvious reasons. The German navy seems particularly careful in this direction. In our opinion, we do not believe that this secretiveness amounts to very much. No military man works on the idea that his enemy is anything but worthy of his steel, and suppression of details are only momentary.

The labor of those who lent their aid to Lord Brassey has been most admirably performed, and due acknowledgement is given Mr. John Leyland and Commander C. M. Robinson, R. N., who had to work at excessively high-pressure in reviewing the progress of the navies and estimating their comparative strength, owing to the regrettable accident to the author, which affected his eyes. Mr. Alexander Richardson writes with his usual interest on engineering matters, and Sir Cyprian Bridge, G. C. B., gives the naval view on the London Declaration. Mr. J. R. Thursfield answered the remarks, and Mr. James R. Corbett on the tactics of Trafalgar, while C. M. Robinson, R. N., writes on the evolution of the battleship since the *Dreadnought* type has come to the fore. It is, of course, difficult, in fact, almost impossible. to give this book its due, as to cut out any of the text is to decrease its value, and yet it is quite impossible to give it in *ex tensio*.

We must admit it is not clear to us why a battle fought 106 years ago, under conditions which could not re-occur, should be commented upon in this naval year book, as it certainly is the "last" utterance on modern navies. Interesting, indeed, are Mr. Thursfield's explanation of Lord Nelson's Trafalgar tactics, but this does not explain the introduction of the matter in Lord Brassey's book.

No one is more conservative than the seafaring man, and he should be, but it does seem to us most curious how some useless things are clung to by navy men. This is instanced by the continued use of the designation "B. L." in connection with the description of guns. No other type could be found in any English modern battleship, therefore why cling to its use either in print or on the breech of the gun, which, of course, would speak for itself?

The points which Lord Brassey's book seem to bring most to the fore are: 1. The assistance which the navies of the colony will render England. 2. The use of internal combustion and steam turbines as motive power. 3. The question of submarine. 4. One-calibre gun ships. 5. Gains in accuracy of fire.

The assistance of colonial navies and their value seem to be points accepted, and there can be no doubt but that the establishment of works for building vessels for these navies in Australia, Canada or other colonies would be most satisfactory for the people and of the very greatest military advantage, and the various colonies seem to be quite willing to furnish funds to carry on the work.

The Declaration of London seems to have been considered advantageous, provided it is shown that foreign governments will stand by its ratification and not pay as little attention to it as was given to the Berlin Treaty.

The question of accuracy of fire is, of course, a determining factor in large guns and long range. In fact, if no hits are made there is no use of any size of gun, and this has been most thoroughly understood and appreciated, and gunnery has

been advanced most satisfactorily. Lord Brassey says: "It is not the number of ships nor the number of guns they carry that will win battles, but the number of effective hits the gunner will make when the target is firing back." No one who has been under fire will take any exception to his Lordship's assertion. The firing back has a most decided influence. Lord Brassey gives high praise to Sir Percy Scott, vice-admiral, and Rear Admirals Frank T. Hamilton and Richard A. Peirse, inspectors of target practice, for the satisfactory results which, under their guidance, have been brought about. The range in firing in ten years has increased from 1½ miles' range to 5 miles, with a great gain in the number of hits at the last-named distance.

In the navigation of the air most nations have given the subject consideration, either with a view of having some aerial vessels of their own or preparing themselves to repel any attack from same. A very large dirigible was completed in England in 1911, it being 512 feet long. It is of the non-rigid type. Just what is the belief of naval men as to the true military value of airships in naval affairs is certainly not clearly brought out by the author.

Submarines and submergibles are a type of design which have to be counted upon in future naval warfare, and, of course, the usual controversy on this subject will go on. The general idea seems to be that very great advance has been made in this class of vessel, and that they will be increased in numbers. Certainly the submarine is no longer considered the idea of a crank, as many can well remember was the case. It seems to be not merely a good "scarecrow" but a practical weapon of offense. Many acts of extreme heroic sacrifices have been brought to notice of those who have manned this type of vessel, actions which bring the tears to one's eyes, and even if the life of many have gone out it has not been in vain. But even in spite of these most regrettable occurrences there seems to be no lack of men to volunteer for service in what must be classed as a risky vocation. Safety devices of various kinds are being tried, some proving successful, and there is no doubt as the years go on the serious accidents of the past will not be repeated.

The motive power of naval vessels is a question which has to be settled from the standpoint of military demands. The internal-combustion engine is under trial. and its advocates have great hopes, and so far it must be admitted great strides have been made in perfecting it, and yet there are many who say that it is not a prime mover to be considered for a vessel of war, and the extensive experiments carried on by quite a number of builders are pronounced by Mr. Richardson "wholly negative."

The steam turbine stays to the fore and various makes are now being tried out, and the usual brisk controversy as to respective merits in a merry war of words is going on concerning them. Which type will be found most effective when all things are considered for navy work is a question which time must answer, but that great improvements may be looked for is beyond doubt. Yet there is a decided tendency not to look upon the reciprocating engine as quite as dead as many have supposed to be. Geared turbines are now being tried, and before the next Annual is printed we should certainly know something absolutely as to the final cost of installing, keeping up and running turbines with reducing gear.

Oil burning is a success beyond any question, but there seems to be a little nervousness as to a possible serious advance in the cost of oil fuel, and that its wide distribution from the various ports of the world will not be rapidly increased.

There seems to be a strong set towards larger guns of a single caliber for ships. The question can be settled finally only after actual warfare, and even then there would be the unconvinced. The gun must be coupled with accuracy of fire, and no one questions the result of an engagement if a large percentage of hits can be made by the large guns. But this accuracy of fire can only be made possible by an increased precision in the range finder, and evidently there is great room for improvement in this instrument, and it seems to us that on its further refinement and perfecting rests the settlement of greater range and heavier weapons.

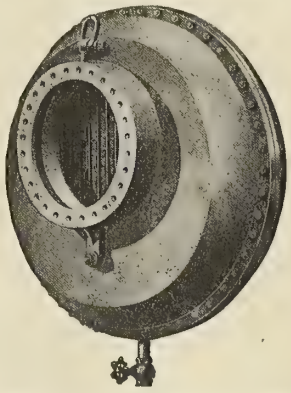
The torpedo does not come in for as prominent a place in weapons of attack as it did years ago. It seems now to be more a weapon of last resort for defense, as is the use of the ram. Still there has been a great increase in the range of torpedoes and a great increase in the accuracy of fire, and, of course, these facts will have a reviving effect on this weapon, and we are inclined to think that its very presence makes towards nervousness, and that most sailors would feel more at ease in an engagement if they knew that there was absolutely no possibility of a torpedo attack.

ENGINEERING SPECIALTIES.

Separators in Connection with Live and Exhaust Steam.

The old idea of prevention instead of cure works out very well in mechanics, and it is a wonder why a steam separator is not just as much a part of all steam systems as is the pipe itself. To prevent the many ill effects of uncontrolled steam is worth while

The Cochrane separator made by the Harrison Safety Boiler Works, Philadelphia, Pa., has been long enough before the public to thoroughly prove its value as a preventor of trouble in steam plants. People seem to forget, or at least fail to recognize, that by use of the separator smaller steam pipes may be used with the corresponding advantage of less first cost and



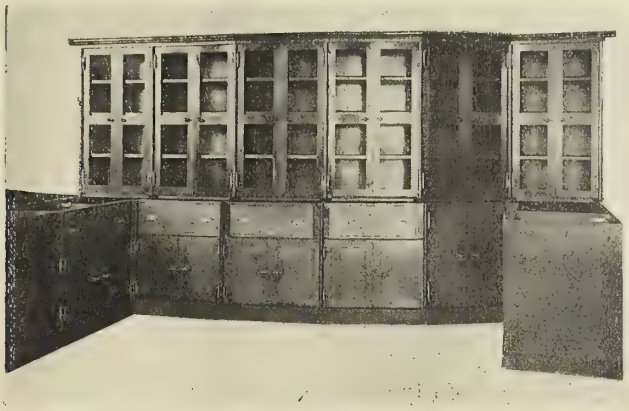
less radiation, which is not a momentarily expenditure, but the source of constant and unnecessary waste, and, further, by its use a less cost of upkeep is to be met, as the water hammer is greatly reduced, and when it does occur it is far less destructive.

This article can be used with the reciprocating engine advantageously, and even more so on steam turbine plants. There is a pretty general idea that a steam turbine is absolutely free from all possible troubles, that there is no trapping of water or knocking off cylinder heads or anything of that kind, and that it can be run with steam of any kind. Steam mixed with oil or water is extremely disadvantageous to steam turbines, and on this account the use of a separator is of great importance.

Ship Furniture in Steel.

The Art Metal Construction Company, Reneo, 26 Holborn Viaduct, London, E. C., is making a specialty of metal furniture and fittings for use on board ship, eliminating wood entirely. Our illustration gives an idea of the neat appear-

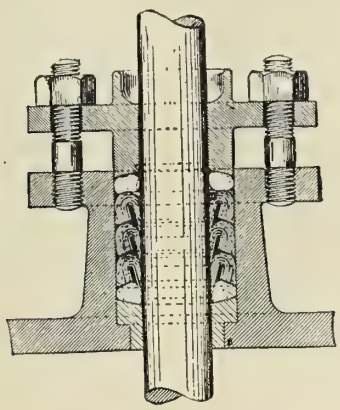
ance of this product. There is no question as to the added safety in case of fire, both in naval and merchant ships. The weight, which one would suppose would be excessive, is not greater than the ordinary construction. There is no swelling and sticking of doors or press drawers, or the annoying

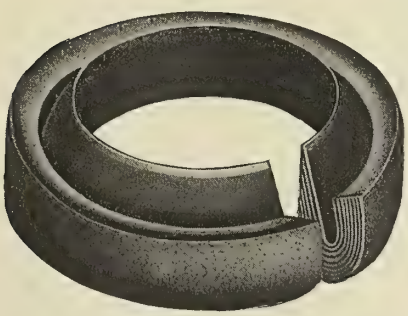


creaking of wooden partitions in heavy weather. The doors are built hollow and filled with asbestos, thus adding to their fire-resisting value.

Automatic Piston Packing.

The H. W. Johns-Manville Company, New York, has secured control of the American rights to the well-known English packing called Sea Rings. The general style of this packing is shown in the accompanying illustration. It consists of a wedge of laminated asbestos, flax or duck turned over upon itself. The rings are believed to be entirely auto-



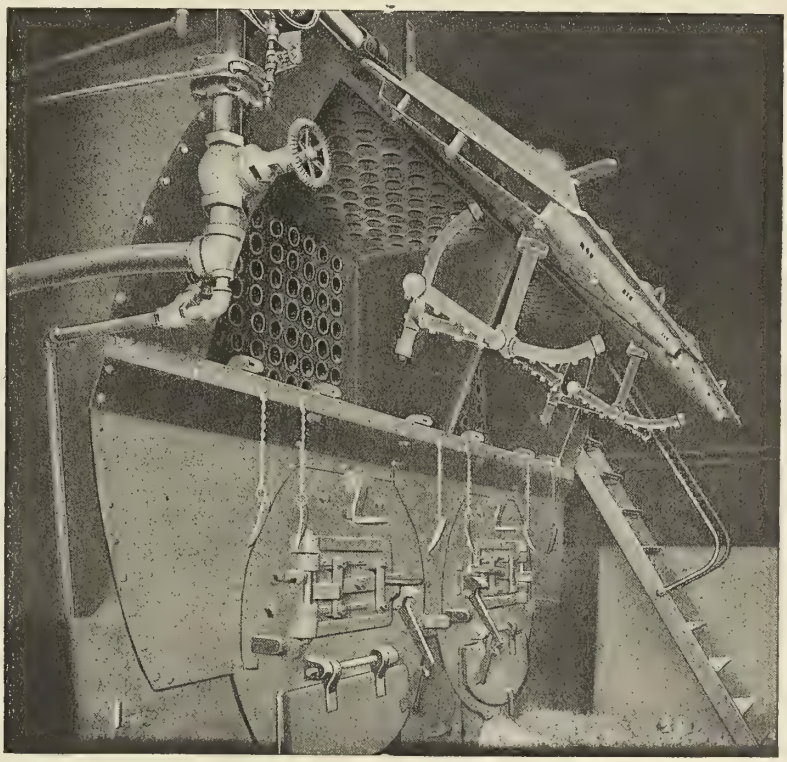


matic, and to give satisfaction under all sorts of conditions. They exert no pressure on the rod except when there is a tendency of leakage past them, and the pressure exerted is never more than what is required to suppress leakage. The rings are designed to withstand temperatures up to at least 600 degrees F., and work on horizontal as well as vertical rods. Although intended especially for marine engines, these rings can also be used on pumps, air compressors, hydraulic machinery, etc. They are recommended highly where superheated steam is used.

A New Front End Soot Blower for Marine Boilers.

The "Diamond" Power Specialty Company, of Detroit, Mich., are again in the front with a brand new type of soot blower which is especially designed for marine boilers. The general construction of this blower, as will be noted from the illustration, is such as to have the blower attached to the smoke-box door in such a way that when the door is opened the entire blower mechanism is withdrawn, thus leaving the boiler end entirely free for repairs, inspection, etc. Another important feature is the fact that the blower can be operated from the outside. This is done by means of the handle which controls the oscillating motion of the arms. These arms are fitted with jets in sufficient quantity to thoroughly cover each tube end, and in the swinging motion the outside tubes, which are most frequently neglected, are specially favored. Attention is also called to the fact that the cross-arms permit of cleaning both the air tubes and fire tubes at the same time. Where it is desired to install this blower on boilers already in use, and where it is not deemed advisable to have special hinges furnished, the pipe line connection is slightly changed whereby it crosses below the door instead of above. This makes a union necessary which may be broken when the door is to be opened.

Considerable interest is shown in the question of loading and unloading ships and providing facilities at terminals for this work, and the question is one which has had closer attention on the lakes than on the sea coast, for the reason that



bulk cargoes are general there, consequently are far easier to handle, but coast conditions demand different treatment. There is certainly a very large volume of business awaiting handling-apparatus builders, and we are surprised that several appliances, which are already on the market, are not more speedily adopted, as they long ago have passed the experimental stage, and their installation is not exceedingly expensive.

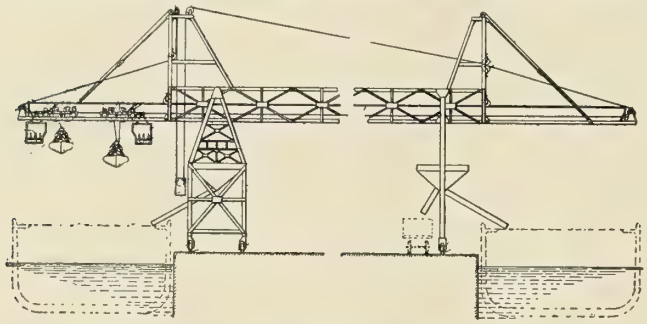
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent attorney, Loan & Trust Building, Washington, D. C.

994,004. APPARATUS FOR ELEVATING, TRANSPORTING AND DISCHARGING MATERIAL. NIKOLINE JOHNSON, OF MILWAUKEE, WIS., ADMINISTRATIX OF OLE JOHNSON, DECEASED.

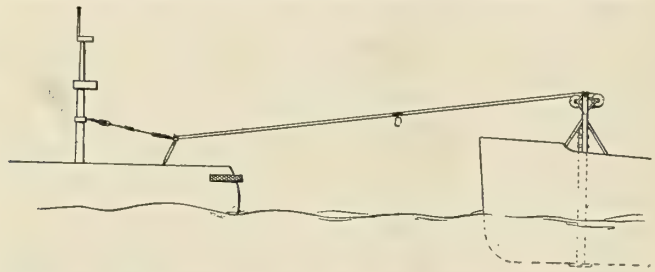
Claim 2.—An apparatus for elevating, transporting and discharging material, comprising a track, a carriage provided with a material holding receptacle adapted to travel on said track, a cable connected to said carriage and extending in the direction of the line of travel of said carriage, another carriage mounted on said track and provided with a material holding receptacle, and a cable connected to said last



mentioned carriage and extending in the direction of the line of travel of said carriage, both cables extending substantially parallel with relation to each other for a certain distance and each cable also extending in the direction of the line of travel of said carriages beyond the carriage other than the one to which it is connected. Forty-two claims.

994,171. CARGO-HANDLING APPARATUS. ONOFRE LINDSAY, OF VALPARAISO, CHILE.

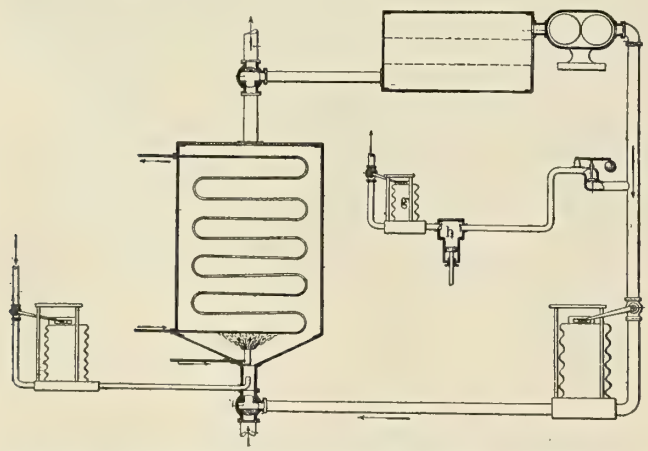
Claim 2. A cargo-handling apparatus, comprising a cableway having one end fixed and the other end movably supported, a counter-



poise releasably connected to the said other end, and an endless haul rope engaging the counterpoise and the said fixed end. Eighteen claims.

994,407. PROCESS FOR UTILIZING STEAM ENGINES FOR THE PROPULSION OF SUBMARINES. GEORGE FRANCOIS JAUBERT, OF PARIS, FRANCE, ASSIGNOR TO ELECTRIC BOAT COMPANY, A CORPORATION OF NEW JERSEY.

Claim 1. The method of supplying motive power for the propulsion of submarine vessels without disclosing their position, which consists in generating steam by heat resulting from the combustion of a mixture of diluted oxygen and hydrocarbon vapor in such proportion

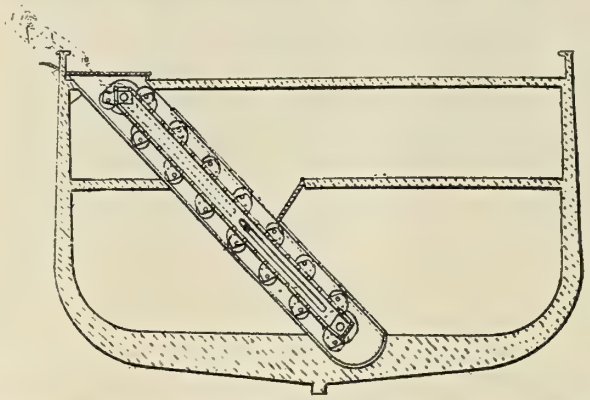


as to give substantially complete combustion utilizing a portion of the products of combustion as the diluent of the oxygen, and disposing of the remainder of the products of combustion by condensation of the water vapor and absorption of the carbon dioxid. Two claims.

British patents compiled by G. E. Redfern & Company, chartered patent agents and engineers, 15 South street, Finsbury, E. C., and 21 Southampton Building, W. C., London.

1,785. DISCHARGING ELEVATOR. J. C. TRAINOR, DUNEDIN, NEW ZEALAND.

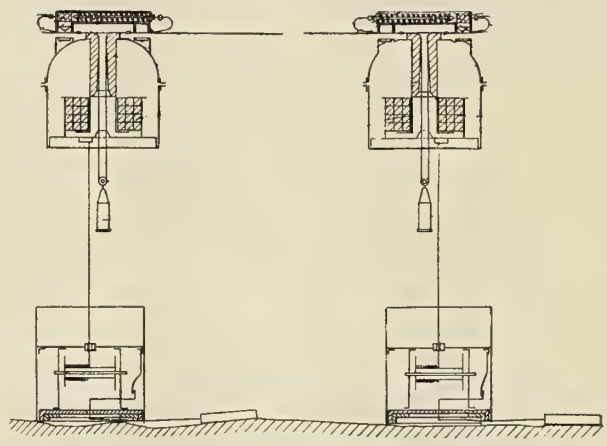
By this invention the elevator is arranged to pass through the various holds and has a casing composed, on its upper side, of slidable doors. The hatches are free for any cargo not lifted by the elevator. Material can be brought to the main elevator by supplementary elevators. An ordinary bucket ladder is used having the bottom tumbler fixed, but the upper part slides out telescopically and is also hinged so as to project



over the bulwarks. The elevator is intended for "colliers" or other ships that carry suitable cargo. It works freely under any cargo, and by moving away any of the removable covers any hold may be emptied in any order desired. In ordinary elevators it is usual to lower the material to the bottom, so that all is lifted the whole height, but here the material is lifted from the top only of each hold, so that much less power is needed in consequence.

12,733. SUBMARINE MINES. VICKERS, SONS & MAXIM, LTD., AND G. E. ELIA, LONDON.

According to this invention the mines are arranged in a row, each being joined by a cable with an adjacent mine and provided with means whereby, when a vessel strikes the cable joining two of the mines, each mine is separated from its outer adjacent mine, so that only the two mines are displaced. When a vessel strikes the cable between two of the mines the cable is pulled and one of the strikers is retracted by means of the ropes; the tension on which then increases until a pin joining the stem with the head is sheared, and each head is impelled forward by its spring and fires the cap of each charge of the projectiles.



These projectiles are then forced through the discs, cutting the cable and ropes at the outer side of each mine, and admitting water to flotation chamber. The casing, containing the detonator and the firing gear of each mine being mounted on the cable by means of a pulley, now drops until a union, which joins the rope to the cable, meets the pulley and prevents the casing becoming detached. This casing is then drawn upwards into a passage; separates this chamber from the anchor by operating a detaching device and finally, by coming into contact with the bush in the passage, causes a striker to be retracted until the tension shears a pin connecting the stem with the head, whereupon the latter fires the detonator, which in turn ignites the bursting charge contained in the flotation chamber.

6,235. PORTABLE VENTILATOR FOR SHIP'S SIDE PORTS. H. HARPER, BELFAST.

This consists of a plate of wood, glass, etc., having on each side, just below the center and near one end, a hinged piece which can be opened out for securing the plate to the sides of the porthole or window, so that it may project vertically from the ship's side and at right angles with it a sufficient distance to catch the wind. At one end of this plate there are projections to prevent it from being forced out of the porthole. When the wind is ahead it strikes upon this plate, passes into and around the cabin and out on the other side of the plate, thus ensuring a continuous current of pure air under these adverse conditions.